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ABSTRACT

Designed to provide students of information science with an introduction to British librarian Samuel Clement Bradford's 1934 findings about the scattering of information, this reader on Bradford's Law begins by discussing its use in calculating search procedures in printed bibliographies as well as in databases. The following additional materials are included in this collection: (1) a biography of Samuel Bradford; (2) bibliographies of works by and about Samuel Bradford; (3) articles by Samuel Bradford, including "Sources of Information on Specific Subjects," "Note on the Scattering of Papers on Specific Subjects in Scientific Periodicals," and "Complete Documentation in Science and Technology," and a chapter on "The Documentary Chaos" from the book, "Documentation"; (4) "Distribution of Citations in Databases in a Multidisciplinary Field" (Carol Tenopir); (5) "Relevante Zeitschriften fur die Veterinarmedizin--Versuch einer Analyse anhand von funf Literatur-Datenbasen" ("Relevant Literature for Veterinary Medicine--An Analysis of Publications Found in Five Databasen") (Wolf D. Hoffmann and Jutta H. T. Klawiter-Pommer); and (6) "Bradford's Law and Libraries: Present Applications--Potential Promise" by M. Carl Drott, Jacqueline C. Mancall, and Belver C. Griffith. The text is supplemented with numerous graphs and charts, and a 197-item bibliography is provided. (EW)

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# Die Informationsgewinnung im Rahmen der "Bradford"schen Streuungsregel (Bradford's Law)

H.-R. Simon

April 1986

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## Vorwort

Informationsgewinnung sollte möglichst rationell im Sinne der Betriebswirtschaftslehre vorgenommen werden. Eine leicht zugängliche Methodik der Optimierung von Recherchen ist die Anwendung der "Bradford-Regel" im Bibliothekswesen, in der Dokumentation sowie in der Informationswissenschaft und -praxis. Die hier vorgelegte Zusammenstellung entstand im Rahmen eines Dokumentationspraktikums im August und September 1984.

Die Materialsammlung und -aufbereitung wurde durchgeführt von Barbara Kremmling, Michaela Lambach und Ursula Lelle. Ihnen allen sei für ihre Mitarbeit herzlich gedankt.

Dank gebührt ferner Herrn Schöndorf für die FIDAS-Programmierung sowie Frau Bill für die Hilfe bei der Konzipierung des Lay-out .

Die Aktualität der Publikation wird durch einen Anhang "Neue Literatur" wesentlich erhöht. Es ist zu hoffen, daß die Schrift anregt, sich in Forschung, Praxis und Lehre mit der "Bradford-Regel" auseinanderzusetzen. Die Schrift hat dann ihren Zweck erfüllt und kann als Vorläufer für weitere Zusammenstellungen dieser Art angesehen werden.

Anregungen und Kritik sind willkommen; bei notwendig werdenden Neuauflagen sollen sie gern berücksichtigt werden.

H.-R. Simon April 1986

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## Erläuterungen

1. Fünfzig Jahre sind vergangen, seit Bradford sein Streuungsgesetz zum ersten Mal schriftlich formulierte. Bradford beschritt mit seinen Forschungen bibliographisches Neuland: die Bibliometrie. Die Bibliometrie im Sinne von Bradford untersucht nicht nur die möglichen Gruppierungen von Zeitschriften hinsichtlich verschiedener Fachgebiete, sondern erstellt eine Rangordnung der Zeitschriften, z. B. innerhalb einer Disziplin. Dabei ist die Produktivität der Zeitschriften und dementsprechend die Verteilung der Artikelanzahl zu einer Spezialfrage wichtiges Kriterium. Diese Verteilung oder "Streuung" eines Themas auf verschiedene Zeitschriften hatte Bradford erstmals untersucht.

2. Ziel dieser Arbeit ist es, die Grundgedanken der Bradford'schen Regel und deren Anwendung verständlich zu machen und Grundlagen für eine weitere Verbreitung und Anwendung derselben zu schaffen. Hierzu erschien es sinnvoll, zunächst eine Kurzbiographie voranzustellen, um ausgewähltes Hintergrundwissen zu vermitteln. Die Regel wird dann in ihrer einfachsten Form erläutert und durch Originalartikel von Bradford selbst vorgestellt. Da im angloamerikanischen Raum bereits sehr viel über mögliche Anwendungsbereiche geschrieben wurde, liegt es nahe, auch die deutschen BID-Praktiker auf diese einfache bibliometrische Methode hinzuweisen.

3. Um eine tiefergehende Beschäftigung mit dem "Law of Scattering" zu ermöglichen, liegt ein Hauptaugenmerk dieser Arbeit auf dem bibliographischen Teil. Die Bibliographie ist typologisch vollständig und selbständig; sie stellt eine durch einen sachlichen Problemkomplex thema-

tisch begrenzte Personal-Sonderbibliographie dar.[1)]
Die Bibliographie besteht zum einen aus sämtlichen Literaturangaben zu Bradford's Law, die in der Datenbank INFO-DATA der Gesellschaft für Information und Dokumentation vorhanden sind (Stand: 07.08.1984). Zum anderen entstand sie durch eigenes Recherchieren

- in den Altbeständen der Bibliothek des Informationszentrums der GID, um den Zeitraum 1934-1975 zu erfassen
- in DATA-STAR
- in dem Science Citation Index in Bezugnahme auf Bradford's ersten Aufsatz von 1934
- in Fachbibliographien:
  a) Bibliometrics : a bibliography and index / by A. Pritchard. - Volume 1 : 1874-1959. - Watford: Allm Books, 1981
  b) A Bibliography of Bibliometrics and Citation Indexing & Analysis / R. Hjerppe. - Stockholm: Stockholm Papers in Library and Information Science, Dec. 1980
  c) Communication research in library and information science : a bibliography on communication in the sciences, social sciences and technology / T. J. Waldhart; S. Waldhart. - Littleton, Colo.: Libraries unlimited, 1975

4. Um einen sachlichen Zugriff auf die formal angelegte Bibliographie zu ermöglichen, erschien es sinnvoll, die Bibliographie durch ein englisches Register, bestehend aus Stichwörtern und zum Teil vereinheitlichten Schlagwörtern, zu erschließen.

5. Die Bibliographie und das Register wurden mit Hilfe des Programmsystems FIDAS (=Formularorientiertes Interaktives Datenbanksystem) erstellt.

1) Prohl, Jürgen: Elemente und Formen der Personalbibliographien zur Deutschen Literaturgeschichte. - Bonn: Bouvier, 1979. - 122 S.

# 1. Biographie

S. C. Bradford

1878 - 1948

Quelle: Gosset, M.: S.C. Bradford
J. of docum. 33(1977)3, pp. 173-176

## 1.1 Samuel Clement Bradford / Biographische Einführung

Vorbemerkung:

Zum Verständnis der Situation, der Motive, aus denen heraus eine Idee oder ein Werk entstanden ist und der Bedeutung, die es für den Urheber hatte, können biographische Informationen recht hilfreich sein. Über S. C. Bradford's Leben und Arbeit existieren mehrere Einträge in allgemeinen und fachlichen Nachschlagewerken. Darüberhinaus finden sich Würdigungen seiner bibliothekarischen, dokumentarischen und wissenschaftlichen Tätigkeit in den Fachzeitschriften. Die wichtigste biographische Literatur, die auch der folgenden Darstellung zugrunde liegt, ist im Anschluß daran aufgeführt.

Samuel Clement Bradford wurde am 10. Januar 1878 in London geboren. Er widmete sich dem Studium der Chemie an der University of London und schloß es während seiner Tätigkeit am Science Museum, South Kensington, wo er seit 1899 arbeitete, mit der Promotion ab.
1901 trat Bradford eine Stelle als "junior assistant" in der Bibliothek des Museums an, deren Leitung er schließlich 1925 übernahm und bis zu seiner Pensionierung im Dezember 1937 innehatte.
In diesem Zeitraum gelang es ihm, den Bestand und die Bedeutung der Bibliothek ganz entscheidend zu erhöhen. Daneben sind zahlreiche Aktivitäten auf den Gebieten der Bibliographie und der Dokumentation zu verzeichenen: 1927 gründete Bradford zusammen mit Professor A. F. C. Pollard[2)] die British Society for International Bibliography (BSIB), die britische Sektion der Fédération International de Documentation (FID). Bradford selbst wurde eines

2) A. F. C. Pollard, Professor für "optical engineering and instrument design" am Imperial College of Science, London

der aktivsten Mitglieder der BSIB und übernahm als Nachfolger Pollards deren Vorsitz. Von 1939 bis zum Aufgehen der BSIB in der Association of Special Libraries and Information Bureaus (ASLIB) gab er überdies die Proceedings of the British Society for International Bibliography heraus.
Auch noch nach dem Eintritt in den Ruhestand blieb S. C. Bradford in diesem Bereich aktiv. Er nahm an zahlreichen Fachkongressen maßgeblich teil, hielt Vorträge und veröffentlichte mehrere Abhandlungen über Aspekte und Probleme der Dokumentation.[3)]
1945 wurde er zum Vize-Präsidenten der FID gewählt und 1947 übernahm er den Vorsitz des International Committees on Classification (ICC), den er bis zu seinem Tode am 13. November 1948 innehatte.

Die Schwerpunkte in Bradford's Tätigkeit lagen, wie schon die Stationen seines Lebenslaufes zeigen, auf dem Gebiet der Dokumentation. Durch sein Studium und seine darüberhinaus andauernde Beschäftigung mit der Chemie lernte er die Probleme des Wissenschaftlers und Forschers bei der Informationssuche aus eigener Erfahrung kennen. Die Auseinandersetzung mit diesen Problemen machte Bradford sich zur Lebensaufgabe.

Wenn über S. C. Bradford's Wirken berichtet wird, so stehen drei Aspekte im Vordergrund: der Ausbau der Science Museum Library, sein Einsatz für die Verbreitung der Dezimalklassifikation (DK) und die Bradford'sche Regel. Als Bradford die Leitung der Science Museum Library übernahm, bestand diese aus einer Büchersammlung für die Verwaltung

3) Diese Publikationen sind auf S. 10 in einer thematisch begrenzten subjektiven Personalbibliographie Bradford's aufgeführt. Grundlage für diese Zusammenstellung ist eine Bibliographie in:
Ditmas, E. M. R.: Dr. S. C. Bradford. - J. of docum. 4 (1948/49) pp. 169-174

des Museums und für die Dozenten des Imperial College of Science der University of London mit einem Lesesaal für Studenten und andere angemeldete Benutzer. Seinen Bemühungen ist es zu verdanken, daß aus dieser Einrichtung die größte Sammlung naturwissenschaftlicher Literatur in Europa entstand, die National Lending Library for Science and Technology (jetzt Teil der British Library Lending Division) und ihr offizielle Beachtung und Unterstützung zuteil wurde.

Bradford's Ziel war die komplette Erfassung der wissenschaftlichen Literatur. Einen wesentlichen Ansatzpunkt dazu sah er in der weltweiten Verwendung der DK, die er enthusiastisch und zum Teil unkritisch als ein allen anderen Klassifikationen überlegenes System befürwortete und in Rede und Tat unterstützte.

Für ihn war die DK der geeignete Weg eine Weltbibliographie aller wissenschaftlich relevanten Literatur mit sparsamsten Mitteln zu erstellen - eine Idee, die schon Paul Otlet und Henri LaFontaine Ende des 19. Jahrhunderts vergeblich zu verwirklichen suchten.

Nachdem S. C. Bradford die Leitung der Science Museum Library übernommen hatte, stellte er deren Systematik auf DK um und versuchte, die Bibliothek zu einem bibliographischen Zentrum zu machen. Er pflegte intensiven Kontakt zu der für die Weiterentwicklung der DK verantwortlichen Institution, dem Institut International de Bibliographie (IIB), das später zur FID umbenannt wurde, arbeitete in verschiedenen Gremien mit und hielt unermüdlich Vorträge über die DK. Bradford veranlaßte auch die Übersetzung der DK aus dem Französischen, doch verschwand das Manuskript der englischen Version nach der Übergabe an die British Standards Institution (BSI), was deren Veröffentlichung stark verzögerte. Im Ganzen gesehen waren seine Bemühungen für die Verbreitung der DK zwar außerordentlich intensiv, jedoch nicht sehr erfolgreich.

Bekannt wurde S. C. Bradford vor allem durch die Formulierung des "Law of Scattering", das die Verteilung von Artikeln über ein bestimmtes Thema auf Zeitschriften, die nicht primär diesen bestimmten Themenbereich behandeln, beschreibt. 271 Zeitschriften wurden dazu anhand zweier Sachgebiete ('geophysics' und 'lubrication') von ihm und seinen Mitarbeitern ausgewertet und das Ergebnis dieser Untersuchungen, in einer allgemeingültigen Formel ausgedrückt, 1934 zum ersten Male veröffentlich[4] und zur Diskussion gestellt.
Es kommt darin zum Ausdruck, daß eine große Zahl von relevanten Artikeln nicht erfaßt wird, da sie sich in Zeitschriften befinden, die sich nicht in erster Linie mit dem betreffenden Sachgebiet befassen. Die Lösung des Problems sah Bradford in der zentralen Auswertung aller Zeitschriften an einer Stelle,deren Durchführbarkeit er jedoch selbst in Frage stellte, oder in der Zusammenarbeit aller Dokumentationseinrichtungen und Fachbibliotheken in einem Informationsverbund, die durch die konsequente und weltweite Verwendung der DK zur inhaltlichen Erschließung ermöglicht werden könnte. Die Bradford'sche Regel verursachte in der Tat große Aufmerksamkeit und Diskussion in Fachkreisen, begegnete unter anderem auch starker Kritik, in der Praxis der Literaturerfassung wurde sie jedoch kaum beachtet.

Einer von Bradford's Nachfolgern an der National Lending Library for Science and Technology[5] würdigte dessen Tätigkeit als eine Pionierleistung, als einen ständigen Versuch, die Notwendigkeit umfassender wissenschaftlicher Information überzeugend darzustellen, die Probleme zu veranschaulichen und Lösungswege aufzuzeigen, die Anregungen gaben und Diskussionen entfachten, selbst wenn sie zum Teil sich als Sackgassen erwiesen.

4) Bradford, S. C.: Sources of information on specific subjects. Engineering (Jan. 26.,1934) pp. 85-86

5) Urquhart, D. J.: S. C. Bradford
J. of docum. 33(1977)3, p. 179

## BRADFORD, SAMUEL CLEMENT [6]

Samuel C. Bradford was born (January 10, 1878) and educated in London, where he earned a doctorate in science from the University of London. He spent his whole professional life in the Science Library at South Kensington, where he started as an assistant in 1899; he was chief librarian there for the period 1925–1938 (*1*).

Being active in the international arena, Bradford was drawn to the work of Henri la Fontaine and Paul Otlet on Classification Décimale, known now as the Universal Decimal Classification (UDC), which they had adopted from the Dewey Decimal Classification to form the basis of the Universal Card Bibliography in 1895 (*2*, p. 94). He realized that though designed for indexing all branches of literature, UDC was only used in the fields of science and technology. Bradford, accordingly, became an avid proponent of UDC and founded, with Professor A. Pollard, Mr. Lancaster-Jones, and Miss M. Gosset, the British Society for International Bibliography in 1895 with a prime objective "to study all the facts concerning the production of documents and the publication of subject-indexes to, and abstracts of, the information recorded therein; to deduce from these facts the most efficient and economic method of organising a comprehensive subject-index with the corresponding abstracts; and to organise the production of such a comprehensive means of locating all recorded information on each topic, large or small" (*2*, p. 100). He also published several articles advocating the use of UDC (*3*). His belief in UDC was based also on the fact that a scholar who one hundred years ago was able to digest the whole existing literature of his special subject, could not do the same today without a current abstracting service. Bradford pointed out that the abstracting periodicals existing in the 1940s were incomplete and accordingly the need for abstracting, or at least indexing, every document was apparent (*3*). He also believed that documents needed not only to be cataloged but also to be classified by subject and as "all scientific progress depends upon recorded facts, subject-indexes to the growing records are more needed than before" (*4*, p. 44).

This was confirmed, around the end of World War II, when Dr. Alingh Prins, director of the Dutch Patent Office, announced that "96% of those who think they have a new invention do not know the facts about it and are repeating . . . work that is already done" (*5*, p. c1).

As the director of the British Society for International Bibliography, Bradford conducted research to investigate, in detail, Dr. Prin's statement, and because the material necessary for such investigation could only be found in large scientific libraries the statistical analysis was made in the Science Library at South Kensington.

By daily examination of the material received in this library, it was found that no more than half the scientific articles published were noticed and/or abstracted by the abstracting and subject indexing periodicals (*5*, p. c1). These examinations also suggested that the deficiency was due to the fact that the individual abstracting agencies concentrated upon the periodicals devoted to their special subjects, depending on the articles within their scope in other periodicals being abstracted by the agencies. Another reason was that the abstracting agencies generally ignored nonperiodical materials such as books, pamphlets, or patents. In other words, the main problem was the scattering of useful articles on a given subject throughout the mass of current published material. Thus it is difficult for one abstracting and/

or indexing agency to find all the pertinent articles in its specialization. This is known as Bradford's Law of Scattering (2, pp. 106–121).

Bradford, however, suggested two solutions: (1) an agency should take the responsibility of abstracting and/or indexing each article in every periodical inclusively; or (2) that abstracting agencies should divide all periodicals into groups according to their subject areas, forwarding along the unrelated articles in the allotted periodicals to those agencies responsible for them (5, p. c5).

The first suggestion was not feasible because of the extreme expenses involved, as the designated agency would end up duplicating the work of existing agencies. The second suggestion, as Bradford noted, involved almost no expense if the UDC were to be adopted. This was exemplified in the formation of a committee of British abstracting agencies and steps of cooperation between them and foreign agencies took place. Bradford, however, warned that comprehensive subject indexing of books and nonbook materials could only be achieved if general scientific libraries, patent offices, and standard institutions in each country adopt the UDC and classify their accession lists according to it (5, p. c5).

Dr. Bradford was an active author. His noted works include various official catalogs, including *Classification of Works on Pure and Applied Science,* second edition, 1921, and third edition, 1936; *Hand List of Short Titles of Current Periodicals in the Science Library,* fourth edition, 1926, and fifth edition, 1938. He also contributed to several scientific and technical journals covering such subjects as "Scientific Apparatus;" "The Kinetic Theory of Gases and Liquids;" "The Molecular Theory of Solution;" "Colloid Solutions;" "The Formation and Structure of Jellies;" "The Crystallisation of Gelatin;" "The Liesegang Phenomenon;" and "The Science of Rose Growing." Among his works on classification and indexing of scientific literature are *The Principles of Classification; The Organisation of Scientific Bibliography;* and *Library Cataloguing.* (See the References for additional works.) He also has written an interesting book on roses (*Romance of Roses,* 1946); growing roses was his favorite recreation (6).

Dr. Bradford was an active member of The Library Association, where he served for several years on its council. He also served on the Executive and the Finance committees of the National Central Library. In the meantime he was interested in international librarianship and founded, in 1927, the British National Section of the International Federation for Documentation (FID), which was amalgamated later with Aslib in 1948. He was elected president of FID in 1945 and later became chairman of the International Committee on Classification.

Dr. Samuel C. Bradford died at the age of seventy on November 14, 1948.

6) Nasri, W. Z.: Bradford, Samuel Clement
in: Encyclopedia of library and information science. - Vol. 3. - pp. 155-157

## 1.2 Biographische Literatur zu S. C. Bradford


1. Bakewell, K. G. B.:
   Bradford, Samuel Clement.
   ALA world encyclopedia of library and information services. - Chicago: Amer. Libr. Assoc., 1980, pp. 96-97

2. Bradford, Samuel Clement
   in: Encyclopedia of librarianship / ed. by T. Landau. - 3. ed. - London: Bowes & Bowes, 1966, p. 71

3. Bradford, Samuel Clement
   in: Who was who. - Vol. 4. - London: Black, 1964, p. 133

4. Ditmas, E. M. C.:
   A chapter closes : Bradford, Pollard and Lancaster-Jones.
   College and res. libr. 10(1949) pp. 332-337

5. Ditmas, E. M. C.:
   Dr. S. C. Bradford.
   J. of docum. 4(1948/49) pp. 169-174

6. Donker, Duyvis, F.:
   S. C. Bradford.
   Rev. docum. 16(1949)1, p. 7

7. East, H.:
   Documentation - Bradford, S. C.
   J. of inform. sci. 7(1983)3, pp. 127-129

8. Gosset, M.:
   S. C. Bradford : keeper of the Science Museum Library 1925 - 1937
   J. of docum. 33(1977)3, pp. 173-176

9. Nasri, W. Z.:
   Bradford, Samuel Clement
   Encyclopedia of library and information science. - Vol. 3. - New York: Dekker, 1970, pp. 155-157

10. Obituary : Samuel Clement Bradford.
    Libr. world 51(1948)Dec., pp. 107-108

11. Urquhart, D. J.:
    S. C. Bradford.
    J. of docum. 33(1977)3, pp. 177-179

## 1.3 S.C.Bradford's Schriften zur Dokumentation[7)]

1. Classification of works on pure and applied science (catalog). - 2nd ed. 1921, 3rd ed. 1936

2. A short account of the Science Library, South Kensington
   Report of the Proceedings of the First Conference (of ASLIB), 1924, pp. 27-29

3. Hand list of short titles of current periodicals in the Science Library (catalog). - 4th ed. 1926, 5th ed. 1938

4. The necessity for the standardisation of bibliographical methods
   Report of the Proceedings of the Fifth Conference (of ASLIB), 1929, pp. 104-113

5. The inadequacy of the alphabetical subject index (in conjunction with Professor A. F. C. Pollart)
   Report of the Proceedings of the Seventh Conference (of ASLIB), 1930, pp. 39-40
   Appendix: Rules for preparing the alphabetical index to the International Classification, pp. 50-52

6. Why the Science Library adopted the Universal Decimal Classification
   Libr. J. 4(13. Dez. 1930)22, pp. 1000-1005

7. The development of scientific bibliography and bibliographical service in Great Britain
   Documentation Universalis (1931)1/2, pp. 5-10
   auch als Übersetzung: Die Entwicklung der wissenschaftlichen Bibliographie und des bibliographischen Quellennachweisdienstes in England
   Sonderdruck aus Minerva-Zeitschrift 7(1931)1/2, S. 6-12

8. Systematic subject indexes to periodical volumes (in conjunction with Professor A. F. C. Pollard)
   Report of the Proceedings of the Ninth Conference (of ASLIB), 1932, pp. 20-30
   außerdem in: Rapport á la Conférence de l'Institut International de Documentation, 1932, pp. 121-152

7) im Wesentlichen entnommen aus:
Ditmas, E. M. R.: Dr. S. C. Bradford
J. of docum. 4(1948/49) pp. 172-174

9. The progress of scientific and bibliographical services in Great Britain
Rapport á la 12me Conférence de l'Institut International de Documentation, 1933, pp. 68-82

10. Bibliography as the basis of co-operation in science
Sci. libr. (1933) pp. 1-7

11. Sources of information on specific subjects+
Engineering (26. Jan. 1934) p. 85
außerdem in: Collection managem. 1(1976/77) pp. 95-103
und in: BSIB publication no. 1 (Jan. 1934)

12. The organisation of a library service in science and technology
IID comm. 3(1936)2, pp. 1-26
außerdem in: Rapport au Congrès du Quarantenaire, Copenhagen, 1935, pp. 1-26. (Reproduced as BSIB publication no. 2)

13. The cataloguing of publications of societies and coporate bodies
IID comm. 3(1936)2, pp. 1-10

14. Subject indexes to volumes of periodicals
IID comm. 3(1936)4, pp. 1-6
außerdem in: BISB publication no. 3

15. The Universal Decimal Classification as the basis of a complete co-operative index to scientific literature
J. of the Institution of Heating and Ventilating Engineers 4(1936)42, pp. 236-245

16. Extent to which scientific and technical literature is covered by present abstracting and indexing periodicals
Report of the Proceedings of the Fourteenth Conference (of ASLIB) 1937, pp. 59-71

17. The British Society for International Bibliography
Report of the World Congress of Universal Documentation, Paris, 1937, pp. 30-31

18. The documentation centre at the Science Library
Report of the World Congress of Universal Documentation, Paris, 1937, pp. 32-35

+ Schriften, in denen Bradford sein Law of Scattering" darstellt.

19. The mobilization of knowledge
Engineering 146(1 July 1938)3781, p. 9 (Letter to the editor)

20. The co-ordination of documentation
Proc. of the BSIB 1(1939)2, pp. 11-15

21. Subject indexes to volumes of periodicals
Proc. of the BSIB 3(1941)3, pp. 41-55

22. Obituary. William Macnab, C.B.E., F.I.C., M.I.Chem.E.
Proc. of the BSIB 3(1941)5, p. 93

23. For and against the Decimal Classification
Proc. of the BSIB 4(1942)4, pp. 76-90

24. Note on the scattering of papers on specific subjects in scientific periodicals+
Proc. of the BSIB 5(1943)3, pp. 74-75
außerdem in: Proc. of the BSIB 6(1944)3, pp. 57-69

25. The Universal Decimal Classification : its origine and purpose, structure and use
Proc. of the BSIB 6(1944)1, pp. 21-36

26. Some general principles of a bibliographical classification scheme, with application to the Universal Decimal Classification
Proc. of the BSIB 6(1944)3, pp. 57-69

27. Availability of scientific information
Chem. age 1(1944)1293, pp. 335-336

28. Obituary. Henri La Fontaine and Paul Otlet
Proc. of the BSIB 7(1945)1, p. 16

29. Fifty years of documentation
Proc. of the BSIB 7(1945)3, pp. 43-51

30. Obituary. Ernest Lancaster-Jones
Proc. of the BSIB 7(1945)3, p. 61

31. The work of the British Society for International Bibliography during the war
IID comm. 12(1945)3/4, pp. 39-55

32. The problems of complete documentation in science and technology +
Proc. of the BSIB 8(1946)3, pp. 39-55

33. Complete documentation in science and technology+
Report of the 16th Conference of the International Federation for Documentation, Paris, 1946, pt. 1, pp. 1-5

34. Complete documentation+
Report of the Royal Society Empire Scientific Conference 1(1946) pp. 729-748
außerdem in: Nat. 159(1947)4029, pp. 105-106

35. Documentation in England during 1946 : some personal reflections
Rev. docum. 14(1947)1, pp. 39-40

36. A plan for complete scientific documentation
Rev. docum. 14(1947)2, pp. 54-56

37. Documentation. - London: Crosby Lockwood, 1948

38. Documentation. - Washington: Public Affairs Press, 1950

39. Documentation. - 2nd ed. - London: Crosby Lockwood, 1953

# 2. Darstellung und Entwicklung der Regel

## 2.1 Die Bradford'sche Regel nach dem Originalartikel

In dem Originalaufsatz "Informationsquellen in speziellen Fachgebieten" vom 26. Januar 1934 beschreibt S. C. Bradford sein Verteilungsgesetz folgendermaßen:
"Wenn man wissenschaftliche Zeitschriften entsprechend der zahlenmäßigen Abnahme der in ihnen enthaltenen Aufsätze über ein gegebenes Thema anordnet, kann man sie einteilen in einen Kernbereich von Zeitschriften, die besonders ergiebig für das Thema sind und in einige Gruppen oder Zonen, die dieselbe Artikelanzahl wie der Kernbereich enthalten. Die Zahl der Zeitschriften im Kernbereich verhält sich zur Zahl der Zeitschriften in den folgenden Bereichen wie $1 : n : n^2 \ldots$

Bradford geht dabei davon aus, daß der Informationsfluß so schlecht funktioniert, daß sich ein Informationsverlust von 2/3 aller vorhandenen Literatur zu einem Sachgebiet ergiebt. Der 2/3-Informationsverlust wird damit begründet, daß nur der Teil der Zeitschriften (1/3), die sich auf das spezielle Gebiet beziehen, berücksichtigt wird. Der größte Teil der Zeitschriftenliteratur aus verwandten und abgelegenen Bereichen (2/3) bleibt unberücksichtigt. Für Bradford ergibt sich daraus die radikale Forderung, daß Zeitschriftenliteratur künftig von den Quellen (Zeitschriften, Zeitungen, Kongreßberichte ...) selbst ausgehend und nicht nach Fachgebieten erfaßt werden müßte. Er denkt dabei an Standardklassifikation und zentrale Dokumentation, die jedoch eine Clearing-Stelle oder Zentralbüros mindestens für jedes Land oder jede Sprache voraussetzen. Nur so hält er einen vollständigen, annähernd lückenlosen Index der wissenschaftlichen Literatur für möglich.
Der folgende Artikel ist eine Vergrößerung von:
Bradford, S. C.: Sources of information on specific subjects
Engineering (26. Jan. 1934) pp. 85-86

# SOURCES OF INFORMATION ON SPECIFIC SUBJECTS.

By S. C. Bradford, D.Sc.

Those who are concerned with progress in science and invention are aware of the need for the provision of an efficient service for abstracting and indexing scientific and technical literature. It is, therefore, somewhat disquieting to find on inquiry that, although the 300 abstracting and indexing journals notice 750,000 articles each year, which is the same as the total number of papers published in their fields; owing to duplication of effort, only 250,000 different articles are dealt with and 500,000 are missed. This is the more difficult to understand when the skill and money spent on these services

Table.—*Applied Geophysics*, 1928-1931, *incl.*

| A. | B. | C. | D. | E. |
|---|---|---|---|---|
| 1 | 93 | 1 | 93 | 0 |
| 1 | 86 | 2 | 179 | 0·301 |
| 1 | 56 | 3 | 235 | 0·477 |
| 1 | 48 | 4 | 283 | 0·602 |
| 1 | 46 | 5 | 329 | 0·699 |
| 1 | 35 | 6 | 364 | 0·778 |
| 1 | 28 | 7 | 392 | 0·845 |
| 1 | 20 | 8 | 412 | 0·903 |
| 1 | 17 | 9 | 429 | 0·954 |
| 4 | 16 | 13 | 493 | 1·114 |
| 1 | 15 | 14 | 508 | 1·146 |
| 5 | 14 | 19 | 578 | 1·279 |
| 1 | 12 | 20 | 590 | 1·301 |
| 2 | 11 | 22 | 612 | 1·342 |
| 5 | 10 | 27 | 662 | 1·431 |
| 3 | 9 | 30 | 689 | 1·477 |
| 5 | 8 | 38 | 753 | 1·580 |
| 7 | 7 | 45 | 802 | 1·653 |
| 11 | 6 | 56 | 868 | 1·748 |
| 12 | 5 | 68 | 928 | 1·833 |
| 17 | 4 | 85 | 996 | 1·929 |
| 23 | 3 | 108 | 1,065 | 2·033 |
| 49 | 2 | 157 | 1,163 | 2·196 |
| 169 | 1 | 326 | 1,332 | 2·513 |

*Lubrication*, 1931–*June*, 1933 (*few* 1933 *refs.*).

| | | | | |
|---|---|---|---|---|
| 1 | 22 | 1 | 22 | 0 |
| 1 | 18 | 2 | 40 | 0·301 |
| 1 | 15 | 3 | 55 | 0·477 |
| 2 | 13 | 5 | 81 | 0·699 |
| 2 | 10 | 7 | 101 | 0·845 |
| 1 | 9 | 8 | 110 | 0·903 |
| 3 | 8 | 11 | 134 | 1·041 |
| 3 | 7 | 14 | 155 | 1·146 |
| 1 | 6 | 15 | 161 | 1·176 |
| 7 | 5 | 22 | 196 | 1·342 |
| 2 | 4 | 24 | 204 | 1·380 |
| 13 | 3 | 37 | 243 | 1·568 |
| 25 | 2 | 62 | 293 | 1·792 |
| 102 | 1 | 164 | 395 | 2·215 |

Column A gives the number of journals producing a corresponding given number of references.
Column B gives the corresponding number of references during the period surveyed.
Column C gives the running sum of the numbers of Column A.
Column D gives the running sum of the numbers of Column B multiplied by A.
Column E gives the common logarithms of Column C numbers.

are realised. It seemed worth while to inquire whether the cause of this failure might not lie in the manner in which the literature of a subject is distributed among the periodicals that contain it, and an investigation was consequently undertaken by Mr. E. Lancaster Jones in the Science Library. The results fully confirm this view.

It might be supposed that the bulk of the papers on a special subject would be published in a few journals specially devoted to that subject, or to the major subject of which it forms a part, together with certain border-line journals and some of the more general periodicals. An alternative hypothesis to be investigated is that, to a considerable extent, the references are scattered throughout all periodicals with a frequency approximately related inversely to the scope. On this hypothesis, the aggregate of periodicals can be divided into classes according to relevance of scope to the subject concerned, but the more remote classes will, in the aggregate, produce as many references as the more related classes. The whole range of periodicals thus acts as a family of successive generations of diminishing kinship, each generation being greater in number than the preceding, and each constituent of a generation producing inversely according to its degree of remoteness.

The investigation covered, in the first place, the references quoted, in the course of four and two and a-half years respectively, by the current bibliographies of Applied Geophysics and Lubrication, which are prepared in the library. The source of each reference being given, it was possible to arrange the sources in order of productivity, the results being set down in columns A and B of the table, in the previous column.

A glance at these figures shows that in each case there are a few very productive sources, a larger number of sources which give moderate production, and a still larger number of constantly diminishing productivity. In each case by far the largest number of sources give only a single reference during the whole period of the survey. No definite boundaries between the various classes are indicated, but the sources can be graded roughly according to the following basis:

a. Those producing more than 4 references a year.
b. Those producing more than 1 and not more than 4 a year.
c. Those prbducing 1 or less a year.

In the case of applied geophysics (see columns C and D):

In class *a* there are 9 sources producing altogether 429 references,
In class *b* there are 59 sources producing altogether 499 references,
In class *c* there are 258 sources producing altogether 404 references.

In lubrication, assuming that practically all the references relate to the two years 1931 and 1932 only,

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| in class *a* there are | 8 | sources | producing | 110 | references |
| „ *b* | „ | 29 | „ | „ | 133 | „ |
| „ *c* | „ | 127 | „ | „ | 152 | „ |

The groups thus produce about the same proportion of references in each case, and the number of constituents increases from group to group, by a multiplier which, though by no means constant, approximates fairly closely to the number 5, especially for the two larger groups. This suggests that the running total number of references given in column D might be proportional to the logarithm of the corresponding number of sources in column C, i.e., to the corresponding number in column E. And, in fact, if curves are plotted, as in Fig. 1, page 86, with E as abscissæ and D as ordinates for both cases, the later portion of each curve is remarkably close to a straight line. We can thus say that the aggregate of references in a given subject, apart from those produced by the first group of large producers, is proportional to the logarithm of the number of sources concerned, when these are arranged in order of productivity.

In the diagram, Fig. 2, let $P_1$ be the point at which the straight line part of the curve commences. Draw $P_1 X_1$ and $P_1 Y_1$ perpendicular to the axes of X and Y respectively. On O Y mark off $Y_1 Y_2$ and $Y_2 Y_3$ each equal $O Y_1$. Draw $Y_2 P_2$ and $Y_3 P_3$ parallel to $Y_1 P_1$, cutting the curve in $P_2$ and $P_3$, and draw $P_2 X_2$ and $P_3 X_3$ both parallel to $P_1 X_1$. Let the distance $O X_1$ be $r$ units and the equal distances $X_1 X_2$ and $X_2 X_3$ be $s$ units in length. Then, if $\alpha$, $\beta$ and $\gamma$ are the natural numbers corresponding respectively to the logarithmic abscissæ $O X_1$, $O X_2$ and $O X_3$, we have

$\log \alpha = r$, or $\alpha = 10^r$
$\log \beta = r + s$, or $\beta = 10^{r+s} = 10^r \times 10^s$
$\log \gamma = r + 2s$, or $\gamma = 10^{r+2s} = 10^r \times (10^s)^2$

Putting $10^s = n$, we see that the natural numbers $\alpha$, $\beta$ and $\gamma$ are related to each other as $1 : n : n^2$

The journals in the group represented by $O X_1$ form a nucleus of those more particularly related to the subject in question. Therefore, the law of

distribution of papers on a given subject in scientific periodicals may thus be stated : if scientific journals are arranged in order of decreasing productivity of articles on a given subject, they may be divided into a nucleus of periodicals more particularly devoted to the subject and several groups or zones containing the same number of articles as the nucleus, when the numbers of periodicals in the nucleus and succeeding zones will be as $1 : n : n^2 \ldots\ldots$

The question now arises, what limit can be assigned either to the aggregate of sources, or the aggregate of references produced, in any given subject ? We know that the former number cannot exceed the total number of current scientific periodicals, say 15,000. But all the data known hitherto relate only to known sources actually discovered in preparing bibliographies. How can we determine whether a mass of sources is in fact absolutely sterile in each subject, and how determine this number ? One approach to this hidden factor is suggested by the scope of the sources actually found. On examination, we can establish the fact that the *a* and *b* groups above are periodicals of scope obviously and *a priori* relevant to the subjects investigated. They are journals which would almost inevitably suggest themselves as being concerned with these subjects, among others. On the other hand, the *c* groups are very mixed, including some sources which, by their scope, we might expect to find more productive; but including also journals of very general scope in which we should hardly expect to find references. We are surprised, on the one hand, by the lack of productivity of the former, and, on the other hand, by the productivity of the latter. We can only draw the general conclusion that a large number of references are produced by sources which, *a priori*, are " unlikely."

Again, if we examine the annual aggregate of sources of references, we find that each successive year brings forth a new crop of sources of references, and that many sources produce a reference one year, but fail in later years. In fact, in the applied geophysics case, each of the four years produced about 40 sources which gave a reference that year and none in the other three years. Also, if we take the successive periods 1929, 1929-30, 1929-31, and 1929-32, *i.e.*, one, two, three and four-year periods, it is found that the number of references arising from sources which produce not more than one reference per annum is, in the four periods, 88, 184, 320, 404 respectively. As each year produces about 350 references, it may be deduced that, in any given

period of years, the c group will produce approximately 25 per cent. to 30 per cent. of the total quantity of references. These will arise from sources which fluctuate over a wide range, and may in the aggregate involve a thousand or more periodicals.

It is conceivable that there could be specified in each of the two test cases a list of a thousand sources that would include all the producers yet found and all which might be found in a ten years' survey. But there is no means of ascertaining the limit necessary in any given case, and no guarantee that in the bibliographical work a considerable number of articles have not been ignored. In the lubrication case, it is significant that a small sample of journals, selected at random from a general list as being possible sources of references, yielded in a ten-year survey 4 " producers " out of 14. These 4 produced only 15 references in the ten years, none producing an average of 1 a year, so that all would come in group c. Out of these 4, only one actually occurs in the list of producers in the bibliography 1931–33, and this one is not in fact the greatest producer in the ten-year period tested. These 14 periodicals examined represented a sample, very small naturally, of the aggregate of regular journals dealing with general science, physical and chemical sciences and engineering and industry. This class would exclude periodicals of the annual or semi-annual type, and those dealing with natural history, medicine and other subjects unlikely to produce references to lubrication. It might thus represent a sample of 14 from an aggregate of say, 3,000 possible periodicals of the former type. As, out of the 14, 4 were found to be productive, we get, as a very rough approximation, a figure of

$$\frac{2}{7} \times 3{,}000 = 850 \text{ (say)}$$

for the number of productive sources in a ten-year period.

Two further tests were made, each based on an examination of the relevant classes in the subject catalogue of the Science Library during a five-year period in which about 500 periodicals, on all branches of science and technology, have been indexed. The tests showed that the lubrication references came from 14 sources, and the applied geophysical references from 19 sources. Assuming that the periodicals indexed by the library represent about $\frac{1}{30}$ $\left(=\frac{500}{15{,}000}\right)$ of the total number of similar periodicals in existence during the five-year period, we get the

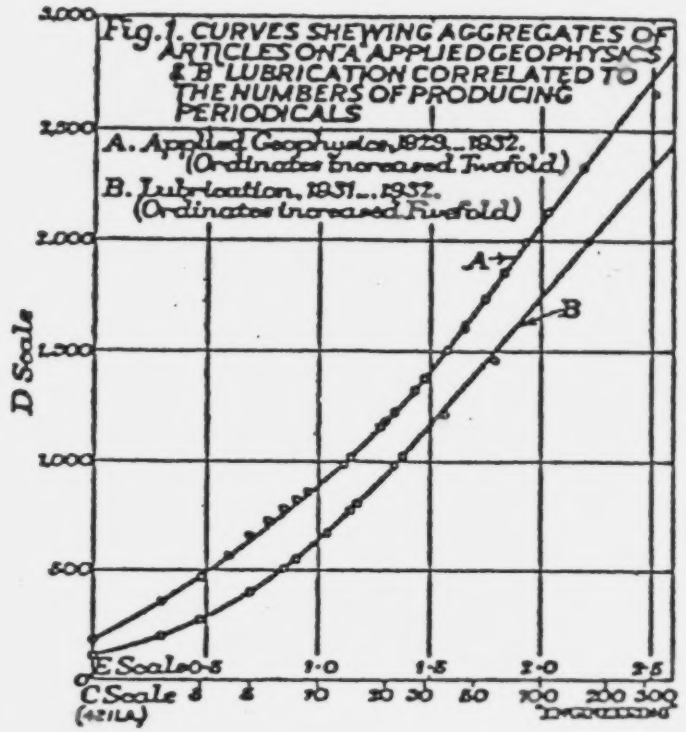
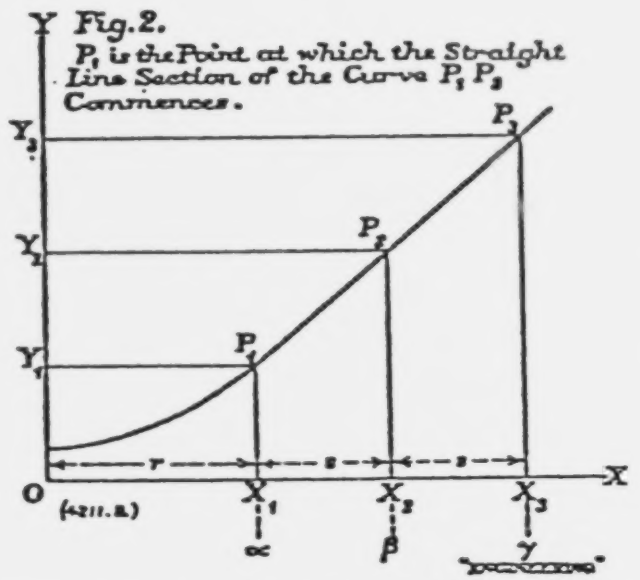


Fig. 1. CURVES SHEWING AGGREGATES OF ARTICLES ON A. APPLIED GEOPHYSICS & B. LUBRICATION CORRELATED TO THE NUMBERS OF PRODUCING PERIODICALS
A. Applied Geophysics, 1929...1932. (Ordinates increased Twofold)
B. Lubrication, 1931...1932. (Ordinates increased Fivefold)
D Scale
E Scale 0·5 1·0 1·5 2·0 2·5
C Scale 5 5 10 20 30 50 100 200 300
(4211A)




figures 14 × 30 = 420, and 19 × 30 = 570 for the numbers of actual sources of references on lubrication and applied geophysics respectively, in a five-year period. These figures are both considerably less than the figure 850 obtained above for lubrication periodicals, which is to be attributed mainly to the difference in the period of the survey, as will be seen.

Other considerations tend to confirm the hypothesis that the number of sources must increase almost linearly with the period of the survey. The numbers of known geophysical sources contributing not more than one reference a year to the bibliography were as follows :—

| | | | |
|---|---|---|---|
| 86 | in the | year | 1929 |
| 155 | „ | 2-year period | 1929–1930. |
| 230 | „ | 3-year „ | 1929–1931. |
| 258 | „ | 4-year „ | 1929–1932. |

and these form the major portion of the known sources, which were respectively 145, 218, 281 and 326. The increments each successive year are 73, 63 and 45, the last figure being probably smaller than it should be, because the survey of the literature of 1932 is still incomplete.

It is reasonable to assume that the known geophysical sources would increase over the whole ten-year period, though the increment might tend to diminish each year, say by 10 per cent.

Thus the number of known sources in a period of $n$ years might be

$$S_n = a + (b + br + br^2 + \ldots \text{ to } n \text{ terms})$$
$$= a + \frac{b(r^n - 1)}{r - 1}$$

where, for the geophysics bibliography,

$$\left.\begin{aligned} a &= 60 \\ b &= 85 \\ r &= \frac{9}{10} \end{aligned}\right\} \text{approx.}$$

giving

$$S_n = 60 + 850\,(1 - 0{\cdot}9^n)$$

or in the limit $S_\infty = 910$.

Again, putting $n = 5$ and 10, successively, we have, for applied geophysics,

$$S_5 = 410$$
$$S_{10} = 615$$

These are the "bibliographical" or "known" sources.

For lubrication, we know that a two-year survey produced 164 bibliographical sources compared with the 218 of applied geophysics, say 25 per cent. less. We can therefore assume, for lubrication

$$S_5 = 310$$
$$S_{10} = 460$$

Comparing $S_s$ here with the value $S'_s = 420$ estimated for the actual sources, we get a figure

$$S'_{12} = 460 \times \frac{420}{310} = 620$$

for the actual or total sources in lubrication, on a ten-year basis. Considering the approximate character of the analysis, this figure is sufficiently comparable with the 850 obtained above.

It seems safe to say, therefore, that the number of journals which contain articles on the subjects in question is of the order of a thousand. But the periodicals themselves could not be specified without scrutinising a much larger number of periodicals during a long period. And even when the actual producers during a period of years had been ascertained, new sources would certainly appear during a further period. It follows that the only way to glean all the articles on these subjects would be to scrutinise continually several thousands of journals, the bulk of which would yield only occasional references or none at all. And because this work is altogether impracticable, a large portion of the total number of references on a given subject is regularly missed by the abstracting journals.

For the same reasons special libraries cannot gather together the complete literature of their subject, except by relinquishing altogether their specific character and becoming practically general libraries of science. In practice one-third of the contents of special libraries is usually related definitely to their scope, the remaining two-thirds comprising literature on border-line and less related subjects. These publications are duplicated in many other libraries, and their representation in any one is altogether inadequate.

In methods of abstracting and indexing, a radical change is needed. Periodical literature must be abstracted by source, and not by subject, as hitherto. All the important articles in each periodical should be catalogued, those coming within the scope of a particular bureau should also be indexed, the titles of the remainder being forwarded to the bureaux specially concerned, or to a clearing house. A standard classification must be adopted, so that references to the same subject would be brought together by the classification, irrespective of source or abstracting bureau, when, without increase of labour, a complete index to scientific literature would be achieved.

## 2.2 Publikationen von S.C. Bradford über die Streuungsregel

a) Note on the Scattering of Papers on Specific Subjects in Scientific Periodicals
in: Proceedings of the British Society for International Bibligraphy 5(1943)3, pp. 74-75

In der folgenden Notiz von 1943 erklärt Bradford, daß seine Regel ganz einfach das Prinzip ausdrückt, daß alle Zweige der Wissenschaft irgendwie in Beziehung zueinander stehen. Wegen dieser "Einheit der Wissenschaft" darf man sich z.B. bei einer speziellen Literatursuche nicht auf spezielle Fachzeitschriften beschränken, sondern muß umfassend recherchieren.

# NOTE

on the

# Scattering of Papers on Specific Subjects in Scientific Periodicals

By S. C. BRADFORD

THE law of scattering described in *Publication* No. 1 was deduced from the examination of two periodical bibliographies prepared in the Science Library and made as complete as current methods would allow. The periods covered by these bibliographies were respectively four and two and a half years, as stated.* These periods represent more than 3% of the life of an ordinary bibliography. The number of journals covered, 490, is more than 3% of the total number of "useful" Scientific Periodicals, and the figures obtained were correlated with others derived from an independent 3% sample of periodicals and checked by search of ten year runs of a number of periodicals chosen at random. A 3% sample is accepted as sufficient for accurate statistical analysis.

The law of scattering deduced is that, if scientific periodicals are arranged in the order of decreasing productivity of articles on a given subject, the periodicals may be divided into a nucleus, more particularly devoted to the subject, and a number of zones, containing the same number of articles on the subject as the nucleus; then the numbers of periodicals in the nucleus and succeeding zones are related as $1 : n : n^2$.

It is easy to show that this law is the simplest expression that can be deduced from the fundamental principle, that all branches of science are related. For, it follows from this principle, that any scientific periodical may, at one time or another, contain an article of interest for any given subject. There are, always, a number of subjects somewhat closely related to any individual subject, and a greater number of subjects more remotely related to it. Therefore, there must be more periodicals covering these related subjects than periodicals specially devoted to the given subject. Those periodicals devoted to the given subject, or to the smallest larger subject containing it, must contain, individually, more articles on that subject than periodicals dealing with related subjects. In consequence, it is possible to arrange periodicals in order of decreasing productivity, in regard to a given subject, and the numbers of periodicals will increase, as their productivity decreases. This is proved to be the case by the figures given in columns A and B of the table in *Publication* No. 1.

* Not three and two as Prof. Pollard suggests.

Let $m$ be the total number of articles, on the subject, contained in the periodicals in the nucleus. Let $p, p_1, p_2 \ldots$ be the numbers of periodicals in the nucleus and succeeding zones, respectively, while $r, r_1, r_2 \ldots$ are the average numbers of articles per periodical in the different classes, where

$$r = \frac{m}{p}, r_1 = \frac{m}{p_1}, \text{ etc.}$$

Thus we have

$$p < p_1 < p_2 < \ldots$$

and, conversely,

$$r > r_1 > r_2 > \ldots,$$

while

$$pr = p_1 r_1 = p_2 r_2 \ldots = m.$$

Consequently,

$$\frac{p_1}{p} = \frac{r}{r_1} = n_1, \text{ say}$$

$$\frac{p_2}{p_1} = \frac{r_1}{r_2} = n_2, \text{ say,}$$

where $n_1$ and $n_2$ are constants greater than unity. So that

$$p_1 = n_1 p$$
$$p_2 = n_2 p_1$$
$$= n_1 n_2 p.$$

Now, we do not know any reason why $n_1$ and $n_2$ should differ, and the simplest supposition we can make is that they are equal. Consequently, in the simplest possible case, we get

$$p : p_1 : p_2 :: 1 : n : n^2,$$

which corresponds exactly to the expression derived, independently, from the actual facts.

We see, therefore, that periodicals, containing information on a particular subject, follow the simplest law that can be deduced from the principle of the Unity of Science. Any further contribution to this fundamental bibliographical subject would be most valuable. But, without any substantial evidence to the contrary, we may take the law of scattering as established.

b) Complete Documentation in Science and Technology
in: FID XVIth Conference (1946), pp. C1-C5
auch veröffentlicht als:
- The Problems of complete Documentation in Science and Technology
in: Proc. of the BSIB VIII (1946), pt. 3, pp. 39-55
- Complete Documentation (in Science and Technology)
in: Report of the Royal Soc. Empire Sci. Conference I (1946), pp. 729-748

In dem Aufsatz von 1946 erläutert Bradford seine Regel noch einmal tiefergehend. Er kritisiert dabei die enorme Doppelarbeit im Bereich technischer Entwicklungen. Es wird aufgezeigt, daß 96% aller angeblich neuen Erfindungen, zumindest schon teilweise bekannt sind und lediglich die Information über sie fehlt. Auf der anderen Seite werden von jedem dokumentationsmässig erfaßten Artikel im Durchschnitt 2,7 Referate erstellt, was im Endeffekt fast Dreifacharbeit bedeutet. Hiermit beanstandet Bradford die Arbeit der vielen individuellen und sehr speziellen Dokumentationsstellen, da sie das Prinzip der Einheit der Wissenschaften ignorieren.
Eine Lösungsmöglichkeit wird angeboten, und zwar die Einrichtung einer großen allgemeinen wissenschaftlichen Bibliothek in jedem Land in Verbindung mit der Verwendung der Universalklassifikation.

# COMPLETE DOCUMENTATION IN SCIENCE AND TECHNOLOGY

by

S. C. BRADFORD, D.Sc. F.L.A.

London.

## Introduction.

Investigators know that, from time to time, researches are pursued in ignorance of recorded facts. They know also that abstracting periodicals do not always abstract important papers on the subjects of their investigations. What they do not know is the extent of these deficiencies. If we would essay the removal of these defects, we must deduce the facts concerning the recording of researches and the subject-indexing, or abstracting, of the records.

The lack of knowledge of inventors of the history of their inventions was established by the Director of the Dutch Patent Office, Dr. Alingh Prins, who showed that hardly ever in technology, inventors know all that has been recorded relevant to their inventions. Some 65 % of German applications for new Patents are refused, because the inventions are not new, and of the 35 % remaining, 31 % are limited in scope, because the inventions are already partly known. This means that 96 % of those, who think they have a new invention, do not know the facts about it, and are repeating, to no good end, with much trouble and expense, work that is already done.

## Collection of the data.

The actual facts, concerning the recording and abstracting of discoveries and inventions, were deduced in detail by the British Society for International Bibliography under my direction. As the material necessary for such investigations could be found in large scientific libraries, only, the statistical analyses were made mainly in the Science Library by a competent mathematician, my late colleague Mr. E. Lancaster-Jones. The Library receives about 200 parts of scientific and technical periodicals a day and takes most of the abstracting journals as well as all the most important separate bibliographies.

By the daily examination of the parts received, it was established that about three quarters of a million useful scientific[1]) papers are recorded every year in 15.000 useful scientific periodicals, and all the 300 abstracting and indexing periodicals, together, publish three quarters of a million abstracts or references. But, examination of these abstracts showed that they related to only about one quarter of a million different papers, each paper being abstracted on an average, about 2.7 times. This means that less than half the useful scientific papers published are abstracted in the abstracting periodicals and more than half the useful discoveries and inventions are recorded, only to lie useless and unnoticed on the library shelves.

## Examination of the literature of a particular subject.

This most disturbing fact demanded exhaustive confirmation. Only the most important of the checks we made we need be recorded here. The total number of current periodical publications, devoted, specifically, to Electrical Engeneering, is rather more than 400, of which more than 200 are of the highest or good class and will be call the "useful" periodicals. The residue are largely semi-technical or economic.

Of the 200 useful journals, 150 are received in the Science Library. All these were critically examined, as received, and were estimated to produce 9.500 useful articles a year.

Consequently 12.000 useful articles may be taken as the annual output of the 200 useful periodicals. Similarly the remaining 200 poor class periodicals were proved to contain about 13.000 papers of less value annually. Some of these articles might, doubtless, be of value. But, for this analysis, they were ignored.

Periodicals, not specifically devoted to Electrotechnology, as those on Physics, Transport, Power, and many other subjects, yield at least half as many articles, as a most conservative evaluation. While general periodicals, books, monographs, pamphlets, patent specifications, standards and Governement reports must yield as many more such useful documents relating to the subject. Thus in all, we find a yearly minimum output of at least 24.000 useful articles and documents relating to Electrotechnology.

In 1936, references to these documents were provided by eleven abstracting and subject-indexing periodicals, devoted to Electrotechnology, producing a total of 27.000 references a year.

While ten general abstracting and indexing periodicals, devoted to pure Science and Engeneering, produced another 18.000 references a year in all. The aggregate of references to papers on the subject by these 21 periodicals, was 45.000.

Further, it was found, that 40 of the 200 useful periodicals were not indexed by any of the 21 sources and no single abstracting or indexing periodical included more than 5.000 references a year.

The 160 periodicals abstracted corresponded to about 10.000 different articles. And, normally, articles in periodicals, not closely related to the broad subject, as well as books, pamphlets and patent-specifications, were hardly noticed by these sources.

A rough determination of the duplication factor, for these references, gave a maximum average figure of 3.9. This figure is considerably higher than the general average 2.7, and is due to the fact that Electrotechnology receives so much attention. Similarly, the proportion of the references produced, 45.000, is high. But, even this large number, corresponds to only 45.000 divided by 3.9, or 11.500 different papers; less than half the annual output of the useful articles. And no one source of references contains more than $^{5}/_{24}$ or 21 % of the aggregate of references to different articles. So that all the 21 sources must be consulted, in their different arrangements, to gather references to less than half the useful records.

A number of similar analyses gave comparable results and thus established that no more than half the useful records of investigation are noticed by the abstracting and subject-indexing periodicals.

1) The term "Scientific" is used, throughout, to cover pure and applied science.

These tests suggested also the real reasons for this imperfection. Individual abstracting agencies concentrate upon the periodicals devoted to their special subjects and a few of those, whose fields are closely allied to these subjects. For articles within their scope in "other" periodicals, these agencies rely upon the agencies concerned to abstract the subject, to which the "other" periodicals more specially relate. This practice does not suffice to pick up the majority of articles on the special subject, published in the "other" periodicals, for the simple reason that these articles are not within the scope of the abstracting agencies, dealing with the other periodicals and are not always abstracted by these agencies.

The other cause of the imperfection is that abstracting agencies generally ignore books, pamphlets, patent specifications and such like.

The Scattering of articles on a given subject.

It is, therefore, necessary to examine the extent, to which articles on a given subject actually occur in periodicals devoted to quite other subjects: as, for instance, a paper on the mechanism of the heart, contributed to the Proceerings of the Physical Society, or one on genetics, occuring in an agricultural magazine. Investigation shows that this distribution follows a certain law, which can be deduced both theoretically from the Principle of the Unity of Science, and practically, from examination of the references.

According to the Principle, every scientific subject is related, more or less remotely, to every other scientific subject.

It follows that, from time to time, a periodical, devoted to a special subject, may contain an article of interest from the point of view of any other subject. In other words, the articles of interest to a specialist, must occur, not only in the periodicals specializing on this subject, but also, from time to time, in other periodicals, which grow in number as the relation of their fields to that of his subject lessens and the number of the articles on this subject in each periodical diminishes.

There are, always, a number of periodicals covering subjects somewhat closely related to any individual subject, and a greater number of periodicals on subjects more remotely related to the given subject. The nucleus of periodicals devoted to the given subject, or to the smallest larger subject containing it, must contain, individually, more articles on that subject than periodicals dealing with related subjects. In consequence, it is possible to arrange periodicals in zones of decreasing productivity, in regard to papers on a given subject, and the numbers of periodicals in each zone will increase, as their productivity decreases.

Let m be the total number of articles, on the subject, contained in the periodicals in the nucleus. Let p, $p_1$, $p_2$... be the numbers of periodicals in the nucleus and succeeding zones, respectively, while r, $r_1$, $r_2$... are the average numbers of articles per periodical in the different zones, where

$$r = \frac{m}{p}, \; r_1 = \frac{m_1}{p_1} \text{ etc.}$$

Thus we have

$$p < p_1 < p_2 < \dots$$

and, conversely,

$$r > r_1 > r_2 > \dots$$

Let us choose the zones sothat

$$pr = p_1r_1 = p_2r_2 \dots = m$$

Consequently,

$$\frac{p_1}{p} = \frac{r}{r_1} = n_1, \text{ say}$$

$$\frac{p_2}{p_1} = \frac{r_1}{r_2} = n_2, \text{ say,}$$

where $n_1$ and $n_2$ are constants greater than unity. So that

$$p_1 = n_1p$$
$$p_2 = n_2p_1$$
$$= n_1n_2p.$$

Now, we know no reason why $n_1$ and $n_2$ should differ, and the simplest supposition we can make is that they are equal. Consequently, in the simplest possible case, we get

$$p:p_1:p_2::1:n:n^2,$$

which corresponds exactly to the expression derived, independently, from the actual facts, as we shall see.

The whole range of periodicals thus acts as a family of successive generations of diminishing kinship, each generation being greater in number than the preceding, and each constituent of a generation producing inversely according to its degree of remoteness.

The investigation covered, in the first place, the references quoted, in the course of four and two and a-half years respectively, by the current bibliographies of Applied Geophysics and Lubrication, which are prepared in the Library. These bibliographies were selected as containing many more than the usual proportion of references on these subjects. All the large collection in the Library of abstracting periodicals being consulted, as well as cumulated references classified by the Universel Decimal Classification, and a large selection of the "other" periodicals being scrutinized as they came in each day.

The source of each reference being given, it was possible to arrange the producing periodicals in order of their bibliographical productivity, the results are set down in columns A and B of the table, as follows:

TABLE.—*Applied Geophysics*, 1928-1931, *incl.*

| A. | B. | C. | D. | E. |
|---|---|---|---|---|
| 1 | 93 | 1 | 93 | 0 |
| 1 | 86 | 2 | 179 | 0·301 |
| 1 | 58 | 3 | 235 | 0·477 |
| 1 | 48 | 4 | 283 | 0·602 |
| 1 | 46 | 5 | 329 | 0·699 |
| 1 | 55 | 6 | 384 | 0·778 |
| 1 | 28 | 7 | 392 | 0·845 |
| 1 | 20 | 8 | 412 | 0·903 |
| 1 | 17 | 9 | 429 | 0·954 |
| 4 | 16 | 13 | 493 | 1·114 |
| 1 | 15 | 14 | 508 | 1·146 |
| 5 | 14 | 19 | 578 | 1·279 |
| 1 | 12 | 20 | 590 | 1·301 |
| 2 | 11 | 22 | 612 | 1·342 |
| 6 | 10 | 27 | 662 | 1·431 |
| 3 | 9 | 30 | 689 | 1·477 |
| 8 | 8 | 38 | 753 | 1·580 |
| 7 | 7 | 45 | 802 | 1·653 |
| 11 | 6 | 56 | 868 | 1·748 |
| 12 | 5 | 68 | 928 | 1·833 |
| 17 | 4 | 85 | 996 | 1·929 |
| 23 | 3 | 108 | 1,065 | 2·033 |
| 49 | 2 | 157 | 1,163 | 2·196 |
| 169 | 1 | 326 | 1,332 | 2·513 |

*Lubrication*, 1931–June, 1933 (*few* 1933 *refs.*).

| | | | | |
|---|---|---|---|---|
| 1 | 22 | 1 | 22 | 0 |
| 1 | 18 | 2 | 40 | 0·301 |
| 1 | 15 | 3 | 55 | 0·477 |
| 2 | 13 | 5 | 81 | 0·699 |
| 2 | 10 | 7 | 101 | 0·845 |
| 1 | 9 | 8 | 110 | 0·903 |
| 3 | 8 | 11 | 134 | 1·041 |
| 3 | 7 | 14 | 155 | 1·146 |
| 1 | 6 | 15 | 161 | 1·176 |
| 7 | 5 | 22 | 196 | 1·342 |
| 2 | 4 | 24 | 204 | 1·380 |
| 13 | 3 | 37 | 243 | 1·568 |
| 25 | 2 | 62 | 293 | 1·792 |
| 101 | 1 | 164 | 395 | 2·215 |

Column A gives the number of journals producing a corresponding given number of articles.

Column B gives the corresponding number of articles during the period surveyed.

Column C gives the running sum of the numbers of Column A.

Column D gives the running sum of the numbers of Column B multiplied by A.

Column E gives the common logarithms of Column C numbers.

A glance at these figures shows that in each case there are a few very productive periodicals a larger number of more moderate producers and a still larger number of constantly diminishing productivity. In each case by far the largest number of periodicals give only a single reference during the whole period of the survey. No definite boundaries between the various classes are indicated, but the periodicals can be graded roughly according to the following basis:

*a*. Those producing more than 4 references a year.

*b*. Those producing more than 1 and not more than 4 a year.

*c*. Those producing 1 or less a year.

In the case of applied geophysics (see columns C and D):

In class *a* there are 9 sources producing altogether 429 references,

In class *b* there are 59 sources producing altogether 499 references,

In class *c* there are 258 sources producing altogether 404 references.

In lubrication, assuming that practically all the references relate to the two years 1931 and 1932 only,

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| in class *a* | there are | 8 | sources | producing | 110 | references |
| „ *b* | „ | 29 | „ | „ | 133 | „ |
| „ *c* | „ | 127 | „ | „ | 152 | „ |

The groups thus produce about the same proportion of articles in each case, and the number of constituents increases from group to group, by a multiplier which, though by no means constant, approximates fairly closely to the number 5, especially for the two larger groups. This suggests that the running total number of articles given in column D might be proportional to the logarithm of the corresponding number of sources in column C, i.e., to the corresponding number in column E. And, in fact, if curves are plotted, as in Fig. 1, page 4, with E as abscissae and D as ordinates for both cases, the later portion of each curve is remarkably close to a straight line. We can thus say that the aggregate of papers in a given subject, apart from those produced by the first group of large producers, is proportional to the logarithm of the number of producers concerned, when these are arranged in order of productivity.

In the diagram, Fig. 2, let $P_3$ be the point at which the straight line part of the curve commences. Draw $P_3 X_3$ and $P_3 Y_3$ perpendicular to the axes of X and Y respectively. On O Y mark off $Y_3 Y_2$ and $Y_2 Y_1$ each equal O $Y_3$. Draw $Y_2 P_2$ and $Y_1 P_1$ parallel to $Y_3 P_3$, cutting the curve in $P_2$ and $P_1$, and draw $P_2 X_2$ and $P_1 X_1$ both parallel to $P_3 X_3$. Let the distance O $X_3$ be $r$ units and the equal distances $X_3 X_2$ and $X_2 X_1$ be $s$ units in length. Then, if $\alpha$, $\beta$ and $\gamma$ are the natural numbers corresponding respectively to the logarithmic abscissae O $X_3$, O $X_2$ and O $X_1$, we have

$\log \alpha = r$, or $\alpha = 10^r$.

$\log \beta = r + s$, or $\beta = 10^{r+s} = 10^r \times 10^s$

$\log \gamma = r + 2s$, or $\gamma = 10^{r+2s} = 10^r \times (10^s)^2$

Putting $10^s = n$, we see that the natural numbers $\alpha$, $\beta$ and $\gamma$ are related to each other as $1 : n : n^2$.

The journals in the group represented by O $X_3$ form a nucleus of those more particularly related to the subject in question. Therefore, the law of distribution of papers on a given subject in scientific periodicals may thus be stated: if scientific journals are arranged in order of decreasing productivity of articles on a given subject, they may be divided into a nucleus of periodicals more particularly devoted to the subject and several groups or zones containing the same number of articles as the nucleus, when the numbers of periodicals in the nucleus and succeeding zones will be as $1 : n : n^2 \ldots$

The question now arises, what limit can be assigned either to the aggregate of periodicals concerned, or the aggregate of articles produced, in any given subject? We know that the former number cannot exceed the total number of useful current scientific periodicals, say 15,000. But all the data known relate to periodicals, actually discovered to contain useful papers, in preparing bibliographies.

How can we determine whether a mass of periodicals is in fact absolutely sterile in each subject, and how determine this number?

One approach to this factor is suggested by the scope of the journals that contain useful papers.

On examination, we can establish that the a and b groups above mentioned are periodicals of scope obviously and a priori relevant to the subjects of investigation. They are journals which would almost inevitably suggest themselves as being concerned with these subjects, among others. On the other hand, the c groups are found to be very mixed, including some periodicals which, by their scope, we might expect to find more productive; but including also journals of very remote scope in which we should hardly expect to find references. We are surprised, on the one hand, by the lack of productivity of the former, and, on the other hand, by the productivity of the latter. We can only draw the general conclusion that a large number of articles are produced by periodicals which, a priori, are "unlikely".

Again, if we examine the annual aggregate of periodicals concerned, we find that each successive year brings forth a new crop of periodicals, and that many periodicals produce a paper one year, but fail in later years. In fact, in the applied geophysics case, each of the four years produced about 40 periodicals which gave a paper that year and none in the other three years.

Also, if we take the successive periods 1929, 1929—30, 1929—31, and 1929—32, i.e., one, two, three and four-year periods, it is found that the numbers of references arising from periodicals which produce not more than one article on the subject per annum is, in the four periods, 86, 184, 320, 404 respectively.

As each year produces about 350 articles, it may be deduced that, in any given period of years, the c group will produce approximately 25 per cent. to 30 per cent. of the total quantity of papers. These will arise from periodicals which fluctuate over a wide range, and may in the aggregate involve a thousand or more periodicals.

It is conceivable that there could be specified in each of the two test cases a list of a thousand periodicals that would include all the producers yet found and all which might be found in a ten years' survey. But there is no means of ascertaining the limit necessary in any given case, and no guarantee that, in the bibliographical work a considerable number of articles have not been ignored.

In the lubrication case, it is significant that a small sample of journals, selected at random from a general

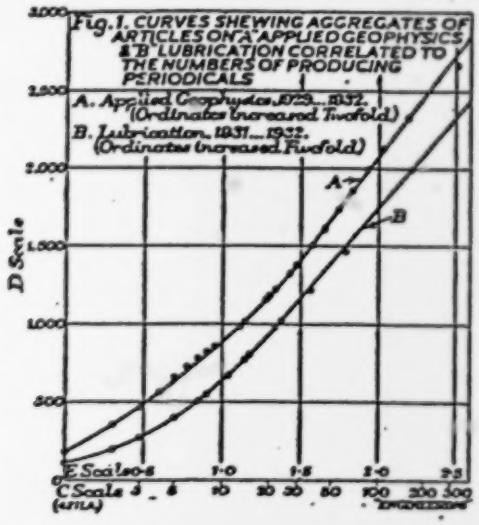
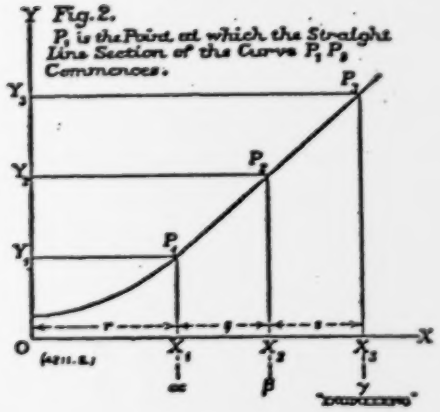


Fig. 1. CURVES SHEWING AGGREGATES OF ARTICLES ON A. APPLIED GEOPHYSICS & B. LUBRICATION CORRELATED TO THE NUMBERS OF PRODUCING PERIODICALS
A. Applied Geophysics 1929—1932. (Ordinates increased twofold.)
B. Lubrication 1931—1932. (Ordinates increased fivefold)
D Scale
A
B
E Scale 50-6 1·0 1·5 2·0 2·5
C Scale 3 6 10 20 30 60 100 200 300
(Units)




list a being possible sources of articles, yielded in a ten-year survey 4 "producers" out of 14. These 4 produced only 15 articles in the ten years, none producing an average of 1 a year, so that all would come in group *c*. Out of these 4, only one actually occurs in the list of producers in the bibliography 1931—33, and this one is not in fact the greatest producer in the ten-year period tested. These 14 periodicals examined represented a sample, very small naturally, of the aggregate of regular journals dealing with general science, physical and chemical sciences and engineering and industry. This class would exclude periodicals of the annual or semi-annual type, and those dealing with natural history, medicine and other subjects less likely to produce references to lubrication. It might thus represent a sample of 14 from an aggregate of say, 3,000 possible periodicals of the former type. As, out of the 14,4 were found to be productive, we get, as a very rough approximation, a figure of

$$\frac{2}{7} \times 3{,}000 = 850 \text{ (say)}$$

for the number of productive sources in a ten-year period.

Two further tests were made, each based on an examination of the relevant classes in the subject catalogue of the Science Library during a five-year period, in which about 500 periodicals, on all branches of science and technology, have been indexed. The tests showed that the lubrication references came from 14 periodicals, and the applied geophysical references from 19 periodicals. Assuming that the periodicals indexed by the library represent about $\frac{1}{30}\left(=\frac{500}{15{,}000}\right)$ of the total number of similar periodicals in existence during the five-year period, we get the figures $14 \times 30 = 420$, and $19 \times 30 = 570$ for the numbers of actual sources of references on lubrication and applied geophysics respectively, in a five-year period. These figures are both considerably less than the figure 850 obtained above for lubrication periodicals, which is to be attributed mainly to the difference in the period of the survey, as will be seen.

Other considerations tend to confirm the hypothesis that the number of periodicals containing articles on the subject must increase almost linearly with the period of the survey. The numbers of known producers contributing not more than one reference a year to the geophysical bibliography were as follows: —

| | | |
|---|---|---|
| 86 | in the year | 1929 |
| 155 | „ 2-year period | 1929—1930. |
| 230 | „ 3-year „ | 1929—1931. |
| 258 | „ 4-year „ | 1929—1932. |

and these form the major portion of the known sources, which were respectively 145, 218, 281 and 326. The increments each successive year, are 73, 63 and 45, the last figure being probably smaller than it should be, because the survey of the literature of 1932 was still incomplete.

It is reasonable to assume that the known geophysical producers would increase over the whole ten-year period, though the increment might tend to diminish each year, say by 10 per cent.

Thus the number of known producers in a period of $n$ years might be

$$S_n = a + (b + br + br^2 + \ldots \text{ to } n \text{ terms})$$
$$= a + \frac{b(r^n - 1)}{r - 1}$$

where, for the geophysics bibliography,

$$\left.\begin{aligned} a &= 60 \\ b &= 85 \\ r &= \frac{9}{10} \end{aligned}\right\} \text{ approx.}$$

giving

$$S_n = 60 + 850\,(1 - 0.9^n)$$

or in the limit, the total number of productive periodicals, $S_\infty = 910$.

Now, putting $n = 5$ and 10, successively, we have, for applied geophysics,

$$S_5 = 410$$
$$S_{10} = 615$$

These are the "bibliographical" or "known" sources.

For lubrication, we know that a two-year survey produced 164 bibliographical sources compared with the 218 of applied geophysics, say 25 per cent. less. We can therefore assume, for lubrication

$$S_5 = 310$$
$$S_{10} = 460$$

Comparing $S_5$ here with the value $S'_5 = 420$ estimated for the actual sources, we get a figure

$$S'_{10} = 460 \times \frac{420}{310} = 620$$

for the actual or total sources in lubrication, on a ten-year basis. Considering the approximate character of the

analysis, this figure is sufficiently comparable with the 850 obtained above.

It seems safe to say, therefore, that the number of journals which contain articles on the subjects in question is of the order of a thousand. But the periodicals themselves could not be specified without scrutinising a much larger number of periodicals during a long period. And, even when the actual producers during a period of years had been ascertained, new sources would certainly appear during a further period. It follows that the only way to glean all the articles on these subjects would be to scrutinise continually several thousands of journals, the bulk of which would yield only occasional references or none at all. And because this work is altogether impracticable, a large portion of the total number of references on a given subject is regularly missed by the abstracting journals.

For the same reasons special libraries cannot gather together the complete literature of their subject, except by relinquishing altogether their specific character and becoming practically general libraries of science. Detailed analysis showed that in practice one-third of the contents of special libraries is usually related definitely to their scope, the remaining two-thirds comprising literature on border-line and less related subjects. These publications are duplicated in many other libraries, and their representation in any one is altogether inadequate.

The law deduced conforms to the mathematician's criterion of being of no possible practical use whatever. But it does show why abstracting periodicals are not complete and points out that, to remove the incompleteness, every useful article in every scientific periodical must be scrutinized, irrespective of its subject.

To complete this investigation, it needs to locate some of the mass of hidden articles on a given subject, which are not indexed by the reference-making periodicals, and to make an independent estimate of the number of these articles from the articles themselves.

We have already shown, how some of these articles were found in Lubrication. Similar searches were made, also, in some other subjects such as chemistry and agriculture. To get a more reliable indication of their extent, it was required to deal with them in bulk. One of the largest groups of abstracting agencies, dealing with a single subject in applied Science, was selected, because of the thoroughness of their abstracting. To avoid offence, the subject shall be nameless. We shall call it "S". One of the largest abstracting bureaux in pure Science kindly allowed its abstractors to scrutinize the periodicals they dealt with for their special subject, we shall call it "R", and to pick out all articles in these periodicals that were of interest for the remotely related subject S. The number of articles a year, relating to the subject S. and not abstracted by its own group of agencies, was found to be about 1,200. These were obtained from a group of 451 periodicals regularly scanned by the abstractors for the subject R. This number corresponds to an aggregate of nearly 40.000 articles on the subject S in the total 15.000 useful scientific periodicals. While the total number of the abstracts on the subject S, produced by its own bureaux, was only 20.000. So that they abstracted only about one third of the useful articles in their special field.

Conclusion.

It has been demonstrated that about 15.000 current scientific periodicals contain about 750.000 useful articles a year. Abstracting and indexing periodicals contain about as many references, but cover less than half these useful articles. The actual existence of the unnoticed articles has been traced and their number estimated independently.

The cause of this deplorable deficiency has been proved to be the scattering of useful articles on a subject, throughout the mass of current periodicals. Which makes it quite impracticable for a single agency to pick out all the useful articles on its special subject.

A comprehensive survey cannot be achieved by such a wasteful method. We must arrange, somehow, that every useful article in every useful periodical is dealt with as it comes out.

There are two different ways of accomplishing this task. Either an organization should be set up to index, or abstract, each useful article in each useful periodical, independent of the subject of the article, or the useful periodicals should be divided into groups, according to the subjects treated by existing abstracting agencies, and these agencies should undertake to notice all the articles, they do not abstract themselves, in the group of periodicals allotted to them, and to pass on the titles of the articles, or the articles themselves, to the agencies interested in them. The former method would be extremely costly and extravagant as well, because it would duplicate the work of the existing skilled bureaux. The method was put to the test, in a smal way, in the well known International Catalogue of Scientific Literature, which dealt with Pure Science only and came to grief. A complete scientific index would be seven times as big.

The latter method needs much less additional expense. Or, possibly, not any, if the Universal Decimal Classification is adopted. No interference is involved with the internal work of any abstracting agency. They can deal with and abstract as many periodicals as they desire, or finance permits, and publish, their abstracts in any form and format, they prefer; all they have to do is to agree to be responsible for a small group of periodicals and to pass on a notice of the articles, they do not treat themselves in this small group, to the agencies concerned with the subjects of these articles.

A Committee of important abstracting agencies in England has been formed, which has accepted this important principle. Some steps towards cooperation have been taken, and it is confidently expected this collaboration will extend as the benefit-arising is experienced, and as the principle is promoted in the other countries. By this means, the abstracting periodicals, on each special subject, will grow more and more complete and only proper subject-indexing is needed to provide the information necessary to prevent the present waste of energy in duplication of research.

The comprehensive subject-indexing of all books, monographs, pamphlets, Governement reports, patent specifications and standards could be achieved by inducing a large general scientific library in each country to classify its accession lists by the Universal Decimal Classification, as does the Science Library and by inducing Patent Offices and Standards Institutions to classify their publications similarly.

I propose that the International Federation for Documentation should officially adopt these principles and use its great influence to promote their application generally.

British Society for International Bibliography.
24 January, 1946.

c) The Documentary Chaos
in: Documentation / S. C. Bradford. - London: Crosby Lockwood, 1948

Bradford liefert in dem Aufsatz "The Documentary Chaos" die endgültige Formulierung seiner Regel. Diese erscheint in dem Buch "Documentation" (1948) und (durch die generelle Zielsetzung des Buches bedingt) in engem Zusammenhang mit der universalen Dezimalklassifikation. Bradford erläutert hier sein ursprüngliches Zahlenmaterial nochmals ausführlich in Beziehung zu seiner Regel. Er kommt zu der erschreckenden Schlußfolgerung, daß weniger als die Hälfte der wissenschaftlich relevanten Artikel durch die laufend dokumentationsmässig ausgewerteten Zeitschriften erfaßt werden. Weiterhin stellt er fest, daß seine mathematisch abgeleitete Gesetzmäßigkeit keinen praktischen Wert besitzt. Somit folgt für ihn zwingenderweise, daß die Unvollständigkeit in der Zeitschriftendokumentation endlich zu beheben sei. Es gilt daher jeden nützlichen Aufsatz in jeder wissenschaftlichen Zeitschrift zu erfassen, unabhängig von der Materie, mit der sich der Aufsatz beschäftigt.

CHAPTER IX

## THE DOCUMENTARY CHAOS

In the previous chapter we have seen that much progress has been made in the co-ordination of documentation. But the leaven of the principles, promulgated by the International Federation, has not yet penetrated into more than half the lump of documentary material. The condition of this unleavened lump is described in the title of this chapter. Documentalists have need to realise the position, before they can consent to join in improving it. The facts have been ascertained. These facts lead to a simple plan for bringing order out of disorder. This plan, which is described in the next chapter, has been adopted by the International Federation for Documentation. But, before the plan can be applied, documentalists have to be convinced that the facts are real and that the simple plan is workable. That is the object of this chapter.

It is important to realise at the outset, as we have seen already, that the making of abstracts of scientific* papers can be achieved only in two stages. In the first stage we endeavour to produce a digest of the main subjects treated in a paper, leaving the very special points of view, the individual compounds dealt with, or the details of the apparatus described, to be treated in the second stage, by the specialists themselves, or by special abstractors, or information officers, working for individual concerns. These special abstractors do not have to deal with all these special points of view, but with only those of particular interest to the organisation that employs them. To serve all these special abstractors, a general abstract would need to include all these special points of view, which would be

* In this and the next chapter, the term scientific is intended to include technical.

impracticable. On an average, a general abstract requires two classification numbers to specify the main subjects of the paper. If there are three-quarters of a million papers to be dealt with, a complete general survey would need a million and a half classification numbers. A special abstract, which included every substance mentioned and every piece of apparatus described, might well need as many as twelve classification numbers. If twelve numbers were required, a complete special survey would need nine million classification numbers annually. As many of these numbers might never be consulted, the task would hardly be worth while. We are obliged in the first stage to be content with only a general survey which will indicate to the special abstractor the papers where he is most likely to discover the information of special interest to himself. General abstracts cannot relieve information officers of the task, which is peculiarly their own. In this chapter, therefore, we confine our attention to general abstracting.

*Statistical Investigation.* For complete realisation of the present bibliographical chaos, the facts must be considered in detail. Investigators know that, from time to time, researches are pursued in ignorance of recorded facts. They know also that abstracting periodicals do not always abstract important papers on the subjects of their investigations. What they do not know is the extent of these deficiencies. If we would essay the removal of these defects we must deduce the facts concerning the recording of researches and the subject-indexing, or abstracting, of the records.

*Collection of data.* The actual facts concerning the recording and abstracting of discoveries and inventions were deduced in detail by the British Society for International Bibliography under my direction. As the material necessary for such investigations could be found only in large scientific libraries, the statistical analyses were made, mainly in the Science Library, by a competent mathematician, the author's late colleague, Mr. E. Lancaster-Jones. The library receives about 200 parts of scientific and technical periodicals a day and takes most of the abstracting journals as well as all the most important separate bibliographies.

By the daily examination of the parts received, it was established that about three-quarters of a million useful scientific papers are recorded every year in 15,000* useful scientific periodicals, and all the 300 abstracting and indexing periodicals together publish three-quarters of a million abstracts or references. But examination of these abstracts showed that they related to only about two hundred and eighty thousand different papers, each paper being abstracted on an average about 2·7 times. This means that *less than half the useful scientific papers published are abstracted in the abstracting periodicals* and more than half the useful discoveries and inventions are recorded, only to lie useless and unnoticed on the library shelves.

*Examination of the literature of a particular subject.* This most disturbing fact demanded exhaustive confirmation. Only the most extensive of the checks we made need be recorded here. The total number of current periodical publications, devoted specifically to electrical engineering, is rather more than 400, of which more than 200 are of the highest or good class and will be called the "useful" periodicals. The residue is largely semi-technical or economic.

Of the 200 useful journals, 150 are received in the Science Library. All these were critically examined, as received, and were estimated to produce 9,500 useful articles a year.

Consequently, 12,000 useful articles may be taken as the annual output of the 200 useful periodicals. Similarly, the remaining 200 poor class periodicals were proved to contain annually about 13,000 papers of less value. Some of these articles might, doubtless, be of use, but, for this analysis, they were ignored.

Periodicals not specifically devoted to electro-technology, as those on physics, transport, power and many other subjects, yield at least half as many articles, at a most conservative evaluation. While general periodicals, books, monographs, pamphlets, patent specifications, standards and government reports must yield as many more such useful documents relating to the subject. Thus, in all, we find a yearly *minimum*



* The remaining 20,000 scientific periodicals contain mostly matter of less importance.

output of at least 24,000 useful articles and documents relating to electro-technology.

In 1936 references to these documents were provided by eleven abstracting and subject-indexing periodicals, devoted to electro-technology, producing a total of 27,000 references a year.

While ten general abstracting and indexing periodicals devoted to pure science and engineering, produced another 18,000 references a year in all. The aggregate of references to papers on the subject by these 21 abstracting periodicals was 45,000.

Further, it was found that only 40 of the 200 useful periodicals, and these the least important, were not indexed by any of the 21 sources but no single abstracting or indexing periodical included more than 5,000 references a year.

The 160 periodicals abstracted corresponded to about 10,000 *different* articles. Normally, articles in periodicals not closely related to the broad subject, as well as books, pamphlets and patent specifications, were hardly noticed by these sources.

A rough determination of the duplication factor, for these references, gave a maximum average figure of 3·9. This figure is considerably higher than the general average of 2·7, and is due to the fact that electro-technology receives so much attention. Similarly, the proportion of the references produced, namely 45,000, is high. But even this large number corresponds to only 45,000 divided by 3·9 or 11,500 different papers ; less than half the annual output of the useful articles. And no one source of references contains more than 5/24, or 21 per cent., of the aggregate of references to different articles. So that all the 21 sources must be consulted, in their different arrangements, to gather references to less than half the useful records.

A number of similar analyses gave comparable results and thus established that no more than half the useful records of investigation are noticed by the abstracting and subject-indexing periodicals.

These tests suggested also the real reasons for this imperfection. Individual abstracting agencies concentrate upon the periodicals devoted to their special subjects with a few of those, the fields of which are closely allied to these subjects. For

I 34 I

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articles within their scope in "other" periodicals, these agencies rely upon the agencies concerned to abstract the subject, to which the "other" periodicals more specially relate. This practice does not suffice to pick up the majority of articles on the special subject, published in the "other" periodicals, for the simple reason that these articles are not within the scope of the abstracting agencies, dealing with the other periodicals and are not always abstracted by these agencies.

Another cause of the imperfection is that abstracting agencies generally ignore books, pamphlets, patent specifications and such-like.

*The scattering of articles on a given subject.* It is, therefore, necessary to examine the extent to which articles on a given subject actually occur in periodicals devoted to quite other subjects: as, for instance, a paper on the mechanism of the heart, contributed to the *Proceedings of the Physical Society*, or one on genetics, occurring in an agricultural magazine. Investigation shows that this distribution follows a certain law, which can be deduced both theoretically from the principle of the unity of science and practically from examination of the references.

According to this principle every scientific subject is related, more or less remotely, to every other scientific subject.

It follows that, from time to time, a periodical devoted to a special subject may contain an article of interest from the point of view of any other subject. In other words, the articles of interest to a specialist must occur not only in the periodicals specialising on his subject, but also, from time to time, in other periodicals, which grow in number as the relation of their fields to that of his subject lessens and the number of the articles on his subject in each periodical diminishes.

There are always a number of periodicals covering subjects somewhat closely related to any individual subject, and a greater number of periodicals on subjects more remotely related to the given subject. The nucleus of periodicals devoted to the given subject, or to the smallest larger subject containing it, must contain, individually, more articles on that subject than periodicals dealing with related subjects. In

consequence, it is possible to arrange periodicals in zones of decreasing productivity, in regard to papers on a given subject, and the numbers of periodicals in each zone will increase as their productivity decreases.

Let $m$ be the total number of articles on the subject contained in the periodicals in the nucleus. Let $p$, $p_1$, $p_2$ . . . be the numbers of periodicals in the nucleus and succeeding zones respectively, while $r$, $r_1$, $r_2$ . . . are the average numbers of articles per periodical in the different zones where

$$r = \frac{m}{p}, r_1 = \frac{m_1}{p_1}, \text{ etc.}$$

Thus we have

$$p < p_1 < p_2 < \ldots$$

and conversely,

$$r > r_1 > r_2 > \ldots$$

Let us choose the zones so that

$$pr = p_1 r_1 = p_2 r_2 \ldots = m.$$

Consequently

$$\frac{p_1}{p} = \frac{r}{r_1} = n_1, \text{ say}$$

$$\frac{p_2}{p_1} = \frac{r_1}{r_2} = n_2, \text{ say,}$$

where $n_1$ and $n_2$ are constants greater than unity. So that

$$p_1 = n_1 p$$
$$p_2 = n_2 p_1$$
$$= n_1 n_2 p.$$

Now we know no reason why $n_1$ and $n_2$ should differ, and the simplest supposition we can make is that they are equal. Consequently, in the simplest possible case, we get

$$p : p_1 : p_2 : 1 : n : n^2,$$

which corresponds exactly to the expression derived, independently, from the actual facts, as we shall see.

The whole range of periodicals thus acts as a family of successive generations of diminishing kinship, each generation being greater in number than the preceding, and each

constituent of a generation producing inversely according to its degree of remoteness.

The actual investigation covered, in the first place, the references quoted in the course of four and two and a half years respectively, by the current bibliographies of applied geophysics and lubrication, which are prepared in the library. These bibliographies were selected as containing many more than the usual proportion of references on such subjects : all the large collection in the Science Library of abstracting periodicals being consulted, as well as cumulated references classified by the Universal Decimal Classification and a large selection of the " other " periodicals being scrutinised as they came in each day.

The source of each reference being given, it was possible to arrange the producing periodicals in order of their bibliographical productivity, the results are set down in columns A and B of tables 1 and 2 as follows :

TABLE 1. APPLIED GEOPHYSICS, 1928-1931 INCLUSIVE

| A | B | C | D | E |
|---|---|---|---|---|
| 1 | 93 | 1 | 93 | 0·000 |
| 1 | 86 | 2 | 179 | 0·301 |
| 1 | 56 | 3 | 235 | 0·477 |
| 1 | 48 | 4 | 283 | 0·602 |
| 1 | 46 | 5 | 329 | 0·699 |
| 1 | 35 | 6 | 364 | 0·778 |
| 1 | 28 | 7 | 392 | 0·845 |
| 1 | 20 | 8 | 412 | 0·903 |
| 1 | 17 | 9 | 429 | 0·954 |
| 4 | 16 | 13 | 493 | 1·114 |
| 1 | 15 | 14 | 508 | 1·146 |
| 5 | 14 | 19 | 578 | 1·279 |
| 1 | 12 | 20 | 590 | 1·301 |
| 2 | 11 | 22 | 612 | 1·342 |
| 5 | 10 | 27 | 662 | 1·431 |
| 3 | 9 | 30 | 689 | 1·477 |
| 8 | 8 | 38 | 753 | 1·580 |
| 7 | 7 | 45 | 802 | 1·653 |
| 11 | 6 | 56 | 868 | 1·748 |
| 12 | 5 | 68 | 928 | 1·833 |
| 17 | 4 | 85 | 996 | 1·929 |
| 23 | 3 | 108 | 1,065 | 2·033 |
| 49 | 2 | 157 | 1,163 | 2·196 |
| 169 | 1 | 326 | 1,332 | 2·513 |

TABLE 2. LUBRICATION, 1931-JUNE 1933 (FEW 1933 REFERENCES)

| A | B | C | D | E |
|---|---|---|---|---|
| 1 | 22 | 1 | 22 | 0·000 |
| 1 | 18 | 2 | 40 | 0·301 |
| 1 | 15 | 3 | 55 | 0·477 |
| 2 | 13 | 5 | 81 | 0·699 |
| 2 | 10 | 7 | 101 | 0·845 |
| 1 | 9 | 8 | 110 | 0·903 |
| 3 | 8 | 11 | 134 | 1·041 |
| 3 | 7 | 14 | 155 | 1·146 |
| 1 | 6 | 15 | 161 | 1·176 |
| 7 | 5 | 22 | 196 | 1·342 |
| 2 | 4 | 24 | 204 | 1·380 |
| 13 | 3 | 37 | 243 | 1·568 |
| 25 | 2 | 62 | 294 | 1·792 |
| 102 | 1 | 164 | 395 | 2·215 |

Column A gives the number of journals producing a corresponding given number of articles.

Column B gives the corresponding number of articles during the period surveyed.

Column C gives the running sum of the numbers of column A.

Column D gives the running sum of the numbers of column B multiplied by A.

Column E gives the common logarithms of column C numbers. 8)

A glance at these figures shows that in each case there are a few very productive periodicals, a larger number of more moderate producers, and a still larger number of constantly diminishing productivity. In each case, by far the largest number of periodicals give only a single reference during the whole period of the survey. No definite boundaries between the various classes are indicated, but the periodicals can be graded roughly according to the following basis :

(*a*) Those producing more than 4 references a year.

(*b*) Those producing more than 1 and not more than 4 a year.

(*c*) Those producing 1 or less a year.

In the case of applied geophysics (see columns C and D):

In class (*a*) there are 9 sources producing altogether 429 references.

In class (*b*) there are 59 sources producing altogether 499 references.

In class (*c*) there are 258 sources producing altogether 404 references.

In lubrication, assuming that practically all the references relate to the two years 1931 and 1932 only :

In class (*a*) there are 8 sources producing 110 references.

In class (*b*) there are 29 sources producing 133 references.

In class (*c*) there are 127 sources producing 152 references.

The groups thus produce about the same proportion of articles in each case and the number of constituents increases from group to group, by a multiplier which, though by no means constant, approximates fairly closely to the number 5, especially for the two larger groups. This suggests that the running total number of articles given in column D might be proportional to the logarithm of the corresponding number of sources in column C, *i.e.* to the corresponding number in column E. And, in fact, if curves are plotted, as in figure 1, with E as abscissae and D as ordinates for both cases, the later portion of each curve is remarkably close to a straight line. We can thus say that the aggregate of papers in a given subject, apart from those produced by the first group of large producers, is proportional to the logarithm of the number of producers concerned, when these are arranged in order of productivity.

In the diagram, figure 2, let $P_1$ be the point at which the straight line part of the curve commences. Draw $P_1X_1$ and $P_1Y_1$ perpendicular to the axes of $X$ and $Y$ respectively. On $OY$ mark off $Y_1Y_2$ and $Y_2Y_3$ each equal $OY_1$. Draw $Y_2P_2$ and $Y_3P_3$ parallel to $Y_1P_1$, cutting the curve in $P_2$ and $P_3$, and draw $P_2X_2$ and $P_3X_3$ both parallel to $P_1X_1$. Let the distance $OX_1$ be $r$ units and the equal distances $X_1X_2$ and $X_2X_3$ be $s$ units in length. Then, if $\alpha$, $\beta$ and $\gamma$ are the natural numbers corresponding respectively to the logarithmic abscissae

$OX_1$, $OX_2$ and $OX_3$ we have

$$\log \alpha = r, \text{ or } \alpha = 10^r.$$
$$\log \beta = r + s, \text{ or } \beta = 10^{r+s} = 10^r \times 10^s.$$
$$\log \gamma = r + 2s, \text{ or } \gamma = 10^{r+2s} = 10^r \times (10^s)^2.$$

Putting $10^s = n$, we see that the natural numbers $\alpha$ $\beta$ and $\gamma$ are related to each other as $1 : n : n^2$.

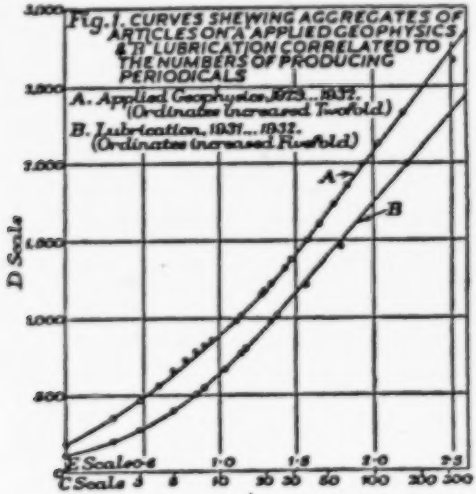
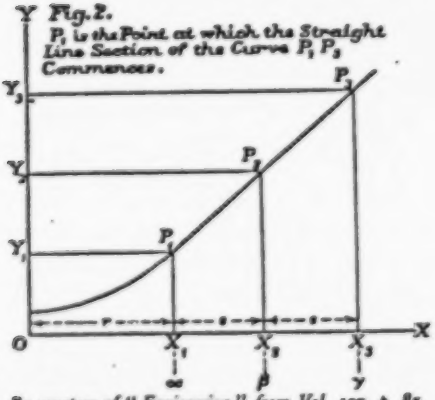


Fig. 1. CURVES SHEWING AGGREGATES OF ARTICLES ON A APPLIED GEOPHYSICS & B LUBRICATION CORRELATED TO THE NUMBERS OF PRODUCING PERIODICALS
A. Applied Geophysics 1923...1932.
(Ordinates Increased Twofold.)
B. Lubrication. 1931...1932.
(Ordinates Increased Fivefold.)
D Scale
A
B
E Scale 0·6 1·0 1·6 2·0 2·3
C Scale 3 6 10 20 30 60 100 200 300




*By courtesy of "Engineering," from Vol. 137, p. 85.*

The journals in the group represented by $OX_1$ form a nucleus of those more particularly relating to the subject in question. Therefore, the law of distribution of papers on a given subject in scientific periodicals may thus be stated: if scientific journals are arranged in order of decreasing productivity of articles on a given subject, they may be divided into a nucleus of periodicals more particularly devoted to the subject and several groups or zones containing the same number of articles as the nucleus, when the numbers of periodicals in the nucleus and succeeding zones will be as $1 : n : n^2 \ldots$

The question now arises, what limit can be assigned either to the aggregate of periodicals concerned, or the aggregate of articles produced, in any given subject? We know that the former number cannot exceed the total number of useful current scientific periodicals, say 15,000. But all the data known relate to periodicals, actually discovered to contain useful papers, in preparing bibliographies.

How can we determine whether a mass of periodicals is in fact absolutely sterile in each subject, and how determine the number of periodicals that contain information on a subject?

One approach to this factor is suggested by the scope of the journals that contain useful papers.

On examination, we can establish that the (*a*) and (*b*) groups above mentioned are periodicals of scope obviously and *a priori* relevant to the subjects of investigation. They are journals which would almost inevitably suggest themselves as being concerned with these subjects, among others. On the other hand, the (*c*) groups are found to be very mixed, including some periodicals which, by their scope, we might expect to find more productive; but including also journals of very remote scope in which we should hardly expect to find references. We are surprised, on the one hand, by the lack of productivity of the former, and, on the other hand, by the productivity of the latter. We can only draw the general conclusion that a large number of articles are produced by periodicals which, *a priori*, are "unlikely."



Again, if we examine the annual aggregate of periodicals concerned, we find that each successive year brings forth a new crop of periodicals, and that many periodicals produce a paper one year, but none in later years. In fact, in the applied

geophysics case, each of the four years produced about 40 periodicals which gave a paper one year and none in the other three years.

Also, if we take the successive periods 1929, 1929-1930, 1929-1931 and 1929-1932, *i.e.* one-, two-, three- and four-year periods, it is found that the numbers of references arising from periodicals which produce not more than one article on the subject per annum is, in the four periods, 86, 184, 320, 404 respectively.

As each year produces about 350 articles, it may be deduced that, in any given period of years, the ($\epsilon$) group will produce approximately 25 to 30 per cent. of the total quantity of papers. These will arise from periodicals which fluctuate over a wide range, and may in the aggregate involve a thousand or more periodicals.

It is conceivable that there could be specified in each of the two test cases a list of a thousand periodicals that would include all the producers yet found and all which might be found in a ten years' survey. But there is no means of ascertaining the limit necessary in any given case, and no guarantee that, in the bibliographical work a considerable number of articles have not been ignored.

To get a general idea of the number of periodicals involved, in the lubrication case, it is significant that a very small sample of journals, selected at random from a general list as being possible sources of articles, yielded in a ten-year survey 4 "producers" out of 14. These 4 produced only 15 articles in the ten years, none producing an average of one a year, so that all would come in group ($\epsilon$). Out of these 4, only one actually occurs in the list of producers in the bibliography 1931-1933, and this one is not in fact the greatest producer in the ten-year period tested. These 14 periodicals examined represented a sample, very small naturally, of the aggregate of regular journals dealing with general science, physical and chemical sciences and engineering and industry. This class would exclude periodicals of the annual or semi-annual type, and those dealing with natural history, medicine and other subjects less likely to produce references to lubrication. It might thus represent a sample of 14 from an aggregate of say, 3,000 possible periodicals of the former type. As, out of the

14, 4 were found to be productive, we get, as a *very rough* approximation, a figure of

$$\frac{2}{7} \times 3{,}000 = 850$$

for the number of productive sources in a ten-year period.

Two more extensive tests were made, each based on an examination of the geophysics and lubrication sections in the subject catalogue of the Science Library during a five-year period, in which about 500 periodicals, on all branches of science and technology, have been indexed. The tests showed that the lubrication references came from 14 periodicals, and the applied geophysical references from 19 periodicals. Assuming that the periodicals indexed by the library represent about

$$\frac{1}{30} = \frac{500}{15{,}000}$$

of the total number of similar periodicals in existence during the five-year period, we get the figures $14 \times 30 = 420$, and $19 \times 30 = 570$ for the numbers of actual sources of references on lubrication and applied geophysics respectively, in a five-year period. These figures, from a proper 3 per cent. sample of periodicals, are both considerably less than the figure 850 obtained above for lubrication periodicals, which is, however, to be attributed mainly to the difference in the period of the survey, as will be seen.

Other considerations tend to confirm the hypothesis that the number of periodicals containing articles on the subject must increase almost linearly with the period of the survey. The number of known producers contributing not more than one reference a year to the geophysical bibliography were as follows :

86 in the year 1929
155 in the 2-year period 1929-1930
230 in the 3-year period 1929-1931
258 in the 4-year period 1929-1932,

and these form the major portion of the known sources, which were respectively 145, 218, 281 and 326. The increments each successive year are 73, 63 and 45, the last figure being

probably smaller than it should be, because the survey of the literature of 1932 was still incomplete.

It is reasonable to assume that the known geophysical producers would increase over the whole ten-year period, though the increment might tend to diminish each year, say by 10 per cent.

Thus the number of known producers in a period of $n$ years might be

$$S_n = a + (b + br + br^2 + \ldots \text{ to } n \text{ terms})$$
$$= a + b\frac{(r^n - 1)}{r - 1}$$

where, for the geophysics bibliography,

$$\left.\begin{aligned} a &= 60 \\ b &= 85 \\ r &= \frac{9}{10} \end{aligned}\right\} \text{approximately}$$

giving

$$S_n = 60 + 850\,(1 - 0{\cdot}9^n)$$

or in the limit, the total number of productive periodicals,

$$S\infty = 910.$$

Now, putting $n = 5$ and 10, successively, we have, for applied geophysics,

$$S_5 = 410$$
$$S_{10} = 615.$$

These are the "bibliographical" or "known" sources.

For lubrication, we know that a two-year survey produced 164 bibliographical sources compared with the 218 of applied geophysics, say 25 per cent. less. We can, therefore, assume for lubrication

$$S_5 = 310$$
$$S_{10} = 460.$$

Comparing $S_5$ here with the value $S'_5 = 420$ estimated for the actual sources, we get a figure

$$S_{10} = 460 \times \frac{420}{310} = 620$$

for the actual or total sources in lubrication, on a ten-year basis. Considering the approximate character of the analysis, this figure is sufficiently comparable with the 850 obtained above.

It seems safe to say, therefore, that the number of journals which contain articles on the subjects in question is of the order of a thousand. But the periodicals themselves could not be specified without scrutinising a much larger number of periodicals during a long period. And, even when the actual producers during a period of years had been ascertained, new sources would certainly appear during a further period. It follows that the only way to glean all the articles on these subjects would be to scrutinise continually several thousands of journals, the bulk of which would yield only occasional references or none at all. And because this work is altogether impracticable, a large portion of the total number of references on a given subject is regularly missed by the abstracting journals.

For the same reasons special libraries cannot gather together the complete literature of their subject, except by relinquishing altogether their specific character and becoming practically general libraries of science. Detailed analysis showed that in practice one-third of the contents of special libraries is usually related definitely to their own scope, the remaining two-thirds comprising literature on border-line and less related subjects. These publications are duplicated in many other libraries, and their representation in any one is altogether inadequate.

The law deduced conforms to the mathematician's criterion of being of no possible practical use whatever. But it does show why abstracting periodicals are not complete and points out that, to remove the incompleteness, every useful article in every scientific periodical should be scrutinised, irrespective of the subject of the article.

*The verification of the proportion of articles not indexed.* To complete this investigation, it needs to locate some of the mass of hidden articles on a given subject, which are not indexed by the reference-making periodicals, and to make an independent estimate of the number of these articles from the articles themselves.

It has been shown how some of these articles were found in lubrication. Similar searches were made also in some other subjects such as chemistry and agriculture. To get a more reliable indication of their extent, it was required to deal with them in bulk. One of the largest groups of abstracting agencies, dealing with a single subject in *applied science*, was selected, because of the thoroughness of their abstracting. To avoid offence, the subject shall be nameless. We shall call it "S." One of the largest abstracting bureaux in *pure science* kindly allowed its abstractors to scrutinise the periodicals they dealt with for their special subject, we shall call it "R," and to pick out all articles in these periodicals that were of interest for the remotely related subject S. The number of articles a year, relating to the subject S and not abstracted by its own group of agencies, was found to be about 1,200. These were obtained from a group of 451 periodicals regularly scanned by the abstractors for the subject R. This number corresponds to an aggregate of nearly 40,000 articles on the subject S in the total 15,000 useful scientific periodicals. While the total number of the abstracts on the subject S, produced by its own bureaux, was only 20,000. So that they abstracted only about one-third of the useful articles in their special field.

We are forced to the conclusion that less than half the useful papers are noticed in the current abstracting and indexing periodicals.

8) A: Anzahl der Zeitschriften, die die entsprechend angegebene Anzahl der Artikel produziert

B: entsprechende Anzahl der Aufsätze während des überwachten Zeitraums

C: fortlaufende Summe der Werte von Spalte A

D: fortlaufende Summe des Produktes aus A und B

E: allgemeiner Logarithmus zu den Werten aus Spalte C

## 2.3 Die Weiterentwicklung der Bradford'schen Regel

Bradford formulierte sein Steuungsgesetz überwiegend verbal und sah von einer genaueren mathematischen Darstellung ab.

Vickery (1948) präzisierte das Modell durch die Formel

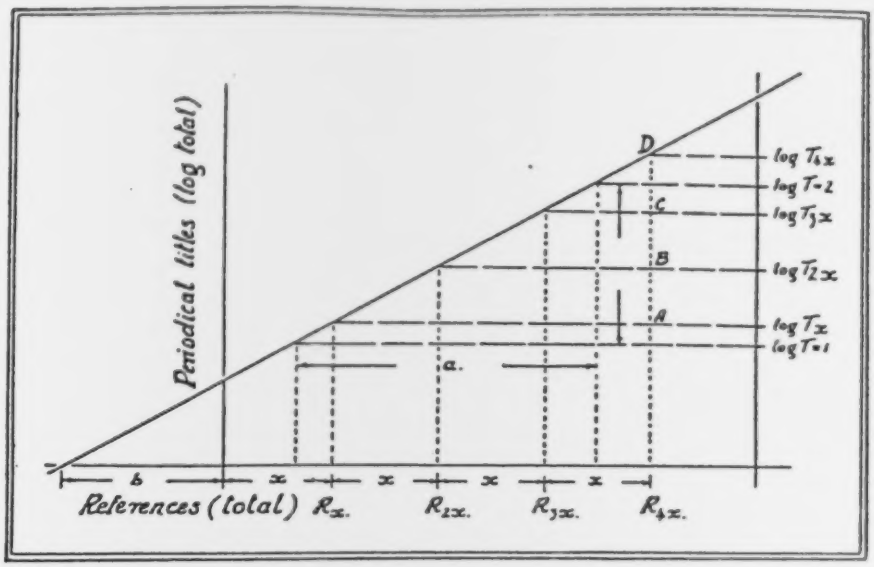
$T_x : T_{2x} : T_{3x} = 1 : p : p^2$

wobei $T_x$, $T_{2x}$, und $T_{3x}$ = die Zahlen der Zeitschriften,

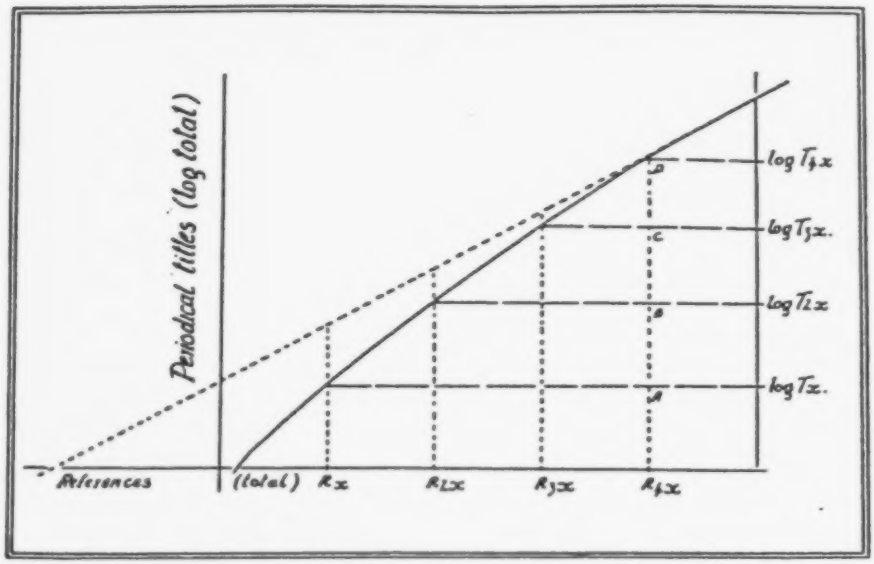
x, 2x und 3x = die Artikel zu einem bestimmten Thema und

p eine von x abhängige Zahl ist, die für jedes Wissensgebiet einen unterschiedlichen Wert besitzt.

Er wies u.a. auch nach, daß man periodische Veröffentlichungen nicht nur in 3, sondern auch in mehrere Gruppen mit jeweils gleicher Produktivität aufteilen kann.



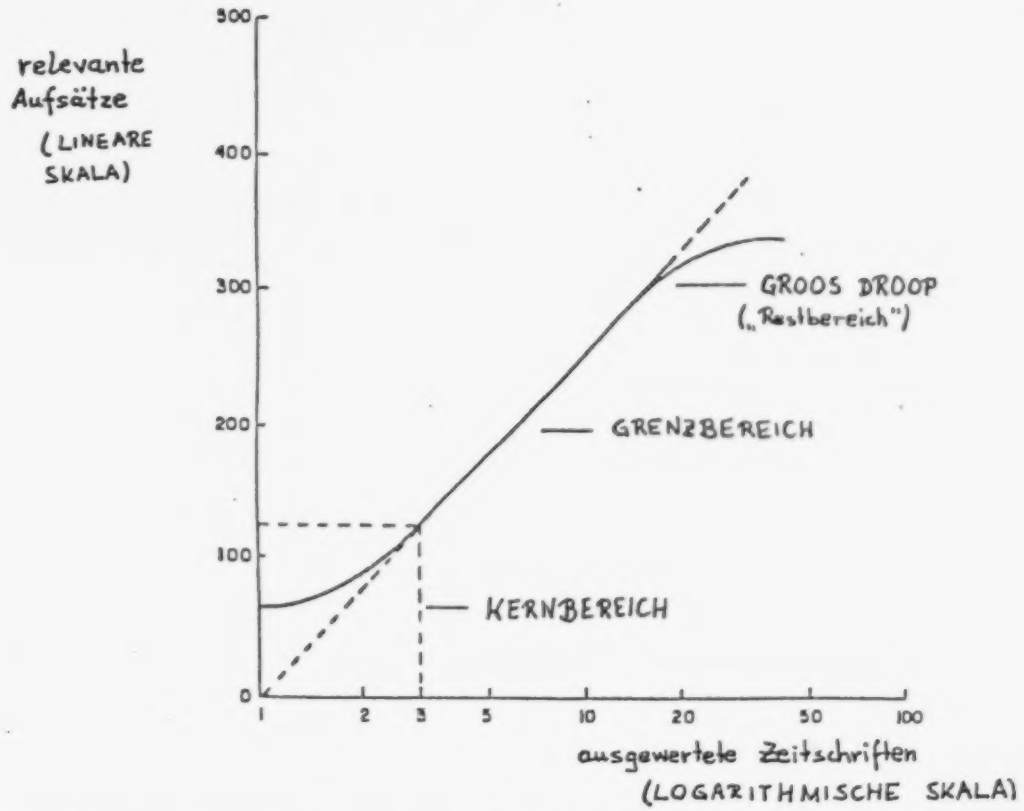

AB = BC = CD




AB > BC > CD

aus: Vickery, B. C.: Bradford's law of scattering
J. of docum. (1948)4, pp. 198-203

Später erschienen mehrere Forschungsarbeiten, auch mit neuem Zahlenmaterial (von Kendall, Cole, Leimkuhler, Morris, Fairthorne...) (1948), die den Wahrheitsgehalt von Bradford's empirischer Regel überprüfen und einen exakteren mathematischen Ausdruck dafür finden wollten.




Graphische Darstellung der Bradford'schen Regel, teilweise übernommen aus:

Cline, G. S.: Application of Bradford's Law to Citation Data. College and res. libr. 42(1981)1, p. 55

Die graphische Darstellung der Bradford'schen Regel erfolgt durch eine Kurve, indem man auf der vertikalen Koordinate die Zahl der relevanten Aufsätze aufträgt und auf der logarithmischen, horizontalen Koordinate die Zahl der ausgewerteten Zeitschriften nach der Rangfolge ihrer Ergiebigkeit ablesen kann.

Die S-förmige Kurve, wie sie heute allgemein verstanden wird, besteht im mittleren Bereich aus einer Strecke, die sich eng an Bradford's ursprüngliches Modell anlehnt. Die untere Krümmung repräsentiert den Kernbereich der relevanten Zeitschriften (Schlüsselzeitschriften). Das obere Ende der Kurve, meistens Groos-Droop genannt, stellt die peri-

phere Zone dar, in der relevante Aufsätze auf eine sehr große Anzahl von Zeitschriften verstreut sind, so daß ab hier eine Recherche eventuell abzubrechen ist, da die Ergiebigkeit linear wächst (=relevantes Material), während die Zahl der zu durchsuchenden Zeitschriften logarithmisch zunimmt.

Wilkinson (1972) analysierte die Disparitäten, auf die Vickery hingewiesen hat und kommt zu dem Ergebnis, daß die graphische Formulierung Bradford's eher mit den tatsächlichen Gegebenheiten übereinstimmt.

Leimkuhler (1966) studierte den Zusammenhang der Größe des Bestandes mit den relevanten Aufsätzen zu einem bestimmten Thema und leitet davon "Bradford's Verteilung" (Bradford distribution) ab. Bradford's Regel ist die Umkehrfunktion zu Bradford's Verteilung: Bradford's Verteilung berechnet die Anzahl der relevanten Artikel ausgehend von einer gegebenen Anzahl an Zeitschriften, während die Bradford'sche Regel von einer gegebenen Anzahl an Artikeln auf die nötige Anzahl der Zeitschriften schließt.

Brookes (1969)machte die Bradford'sche Regel schließlich einem größeren interdisziplinären Publikum bekannt, indem er in der Zeitschrift "Nature" seine Anwendung auf das Bibliothekswesen beschrieb.

Bonitz[9)] beschreibt die Bradford'sche Regel im Zusammenhang mit Rangverteilungen:

"Eine Folge von Objekten, die nach einem bestimmten Merkmal angeordnet sind (das diesen Objekten in ungleichem Maße eigen ist), wird geordnete Folge genannt. Der Prozeß dieses Ordnens selbst heißt 'Rangieren': jedem Glied der Folge wird dabei ein 'Rang' verliehen... Es ist üblich, daß die Objekte bei der Aufstellung von Rangfolgen dergestalt rangiert werden, daß die Merkmalshäufigkeit mit zunehmendem

9) Bonitz, M.: Rangverteilungen
in: Wissenschaftliche Forschung und wissenschaftliche Information. - Berlin, 1979. - S. 127-130

Rang abnimmt: je höher der Rang des Objektes, desto seltener ist das Merkmal in dem Objekt vertreten. Je höher beispielsweise der Rang einer Zeitschrift ist, desto weniger sind in ihr Arbeiten des betreffenden Gebietes enthalten. ... Aussichtsreich erscheint vor allem die Erforschung von Rangverteilungen an großen Informationsmassiven. Sie wird in dem Maße zunehmen, in dem die Massive selbst wachsen und Aufbereitung der Informationen sowie rechnergestützter Zugriff zu ihnen es erlauben, die Objekte - den gewünschten Merkmalen entsprechend - in den Massiven aufzufinden und zu Rangfolgen zusammenzufügen."

Wenn auch die Bradford'sche Regel vielfach verfeinert und weiterentwickelt wurde, so ändert dies nichts daran, daß die Mängel im Informationfluß auch heute noch bestehen. Die notwendige Konsequenz einer radikalen Änderung der gesamten Dokumentationsverfahren, wie sie Bradford mehrfach forderte, und somit die konsequente Anwendung der Regel blieb bisher aus.

## 2.4 Chaos in der Dokumentation: Bradford's Folgerungen und sein "Law of Scattering"

Bradford (1948) gibt folgende allgemeine Informationen zur Literaturentwicklung: Es erscheinen

15 000 "nützliche" wissenschaftliche Zeitschriften

\+ 20 000 Zeitschriften, die meist Mitteilungen von "geringerer" Bedeutung enthalten

= 35 000. Die genannten 15 000 Zeitschriften publizieren 750 000 Aufsätze p.a.

300 Abstracting-&-Indexing-Zeitschriften publizieren 750 000 Abstracts oder Referenzen. Durch Mehrfachverzeichnung reduziert sich die Zahl der Originalbeiträge auf

280 000 Aufsätze p.a., d.h., jeder Beitrag wird 2,7 mal referiert oder verzeichnet. Dies bedeutet, daß "weniger als die Hälfte der 'nützlichen' wissenschaftlichen Aufsätze in den Abstracting-&-Indexing-Diensten angezeigt werden".

Die Berechnung ergibt:

750 000 "nützliche" Aufsätze, abzüglich

280 000 in Sekundär-Diensten angezeigten Aufsätze und führt somit zu einem Defizit von

470 000 <u>nicht verzeichneten</u> "nützlichen" Publikationen.

Diese generelle Beobachtung wird nun übertragen auf ein spezielles Fachgebiet, Electrical Engineering, und dessen Informations'lage'. Hierzu führt Bradford aus:

| | | |
|---|---|---|
| Es existieren (1948) mehr als | 400 | Spezialzeitschriften. |
| Davon sind | 200 | |
| von höchster oder guter Qualität und werden daher von ihm wieder mit dem Prädikat "nützlich" versehen. Von diesen 200 Titeln erhält die Science Library (des Science Museum; London-Kensington) | 150 | Titel. |
| Eine"kritische Durchsicht" ergibt | 9.500 | "nützliche" Publikationen |

pro Jahr.

Ein Vergleich mit den Angaben zu allen "nützlichen wissenschaftlichen" Zeitschriften ergibt:

750.000 : 15.000 = 50 Aufsätze pro Zeitschrift und Jahr.

Für die Gruppe Electrical Engineering:

9.500 : 150 = 60,6 ≈ 61 Aufsätze pro Zeitschrift und Jahr.

Beide Durchschnittszahlen erscheinen (auch im Lichte neuerer Untersuchungen, vgl. Simon, 1983, S. 31-32 und S. 210-221[10]) realistisch. Ein Indiz auf eine exaktere Methodik könnte die Gruppe Electronical Engineering mit dem Aufsatzwert 60 p.a. pro Zeitschrift sein.

Hochgerechnet auf 200 tatsächlich erscheinende "nützliche" Zeitschriften ergeben sich 60 x 200 = 12.000 "nützliche" Aufsätze pro Jahr.

10) Research and publication trends in systematic zoology, 1758 - 1970. - Ber. ökol. Aussenst. Schlüchtern der J. W. Goethe-Univ., Frankfurt a. M., H. 11. - 1983. - 403 S.

Andere als Fachzeitschriften (z.B. Physik-, Transport-, Energie- und andere Zeitschriften) enthalten die übrige Hälfte der Publikationen (= 6.000), wenn man sehr zurückhaltend schätzt. Dazu kommen noch Monographien, Patente, Reports, ..., so daß der jährliche output ca. 24.000 Publikationen p.a. zum Fachgebiet beträgt.

Im Jahre 1936 erschienen in 11 A&I-Diensten der Elektro-Technologie 27.000 Abstracts oder bibliographische Angaben.
Außerdem bringen 10 generelle Verzeichnisse 18.000 Angaben zum Spezialgebiet, insgesamt also 45.000 Hinweise, d.h. bei insgesamt 45.000 Angaben und 21 Diensten finden wir pro Dienst ca. 2.143 relevante Hinweise. Von den 200 "nützlichen" Zeitschriften wurden 160 durch Sekundär-Dienste ausgewertet; es ergaben sich Hinweise auf 10.000 unterschiedliche Publikationen.

Eine Nachrechnung [11] unter Benutzung von Bradford's Angaben zeigt, daß jede "nützliche" Arbeit 4 x verzeichnet wurde (Bradford schreibt "3,9 mal").
Insgesamt werden also 45.000 : 4 = 11.250 (etwa) als einmalig aus den übrigen zu selektieren sein. Das ist weniger als 50% der jährlich (geschätzten) Publikationen von 24.000 Aufsätzen, Monographien usw.

Da kein Dienst vollständig war, mußte in allen 21 Sekundärpublikationen recherchiert werden.

11) 160 Zeitschriften sollen 10.000 unterschiedliche Publikationen enthalten; d.h. pro Zeitschrift 55 Aufsätze p.a. Hochgerechnet auf alle 200 Zeitschriften (55 x 200) = 11.000 unterschiedliche Aufsätze. Bei 45.000 Hinweisen ca. 45 : 11 = 4,09 mal wurde jede Arbeit im Durchschnitt verzeichnet.

Diese Tests (und einige andere, jedoch von Bradford nicht speziell angeführt) haben ergeben, daß sich die Informationsdienste auf den Bereich der Fachzeitschriften "ihres" Gebietes konzentrieren, und daß ferner Monographien, Broschüren, Patente ... nur sehr ungenügend berücksichtigt werden.

Von diesen Beobachtungen ausgehend kommt Bradford zum Problem der "Streuung von Aufsätzen über ein gegebenes Thema".

Vor allem ist (neben der zunächst vorzunehmenden Auswertung von direkt dem Fragekomplex gewidmeten Spezialzeitschriften) auch diejenige Literatur sorgfältig auszuwerten, die anderen Problemen gewidmet ist, z.B. eine Arbeit über Genetik, die in einer landwirtschaftlichen Zeitschrift erscheint und auch den an der Grundlagenforschung orientierten Genetiker interessieren kann.
Allgemein gesehen, kann man feststellen, daß von Zeit zu Zeit eine Zeitschrift, die einem Spezialgebiet gewidmet ist, auch solche Aufsätze bringt, die ebenso Bedeutung für ein anderes Spezialgebiet besitzen.

Der Kern von Periodika, die einem Spezialgebiet dienen, muß folglich mehr Aufsätze zu diesen Fachthemen enthalten als Zeitschriften, die sich mit benachbarten Problemstellungen und Fachfragen befassen. Als Schlußfolgerung ergibt sich die Möglichkeit, Periodika in Zonen abnehmender Produktivität zu ordnen, und zwar in Bezug zu den Aufsätzen über eine Spezialfrage. Die Anzahl der zu berücksichtigenden Zeitschriften wird in dem Verhältnis zunehmen, in dem ihre Produktivität abnimmt.

Die Beziehungen sollen sich folgendermaßen darstellen, wenn man die Definitionen, die Bradford einführt, berücksichtigt:

m = Totale der Aufsätze über ein Spezialthema, die in den Periodika des Kerns (= ergiebigste Zone) enthalten sind

$p$, $p_1$ ... = Anzahl der Periodika im Kernbereich und in den folgenden Zonen

$r$, $r_1$ ... = Durchschnittliche Anzahl der Aufsätze pro Zeitschrift in den verschiedenen Zonen.

Danach ist

$$r = \frac{m}{p} \text{ und } r_1 = \frac{m_1}{p_1} \text{ usw.}$$

und $p < p_1 < p_2 \ldots$

sowie $r > r_1 > r_2 \ldots$

Die Zonen sind so auszuwählen, daß,

$$pr = p_1 r_1 = p_2 r_2 = m$$

d.h., daß jede Zone (ungefähr) die gleiche Produktivität aufweist.
Konsequenterweise sollte das Verhältniss

$$\frac{p_1}{1} = \frac{r}{r_1} = n_1$$

und $$\frac{p_2}{p_1} = \frac{r_1}{r_2} = n_2 \quad \text{sein.}$$

Daher ist

$$p_1 = n_1 p$$
$$p_2 = n_2 p_1$$
$$= n_1 n_2 p$$

Die Periodika p stehen in der Verhältnisfolge

$$p : p_1 : p_2$$

die den Verhältniswerten der Folge $1 : n : n^2$ entspricht.

Als Ergebnis seiner Untersuchungen faßt Bradford zusammen:
Beispiel-Bibliographie "angewandte Geophysik" (A)

Klasse a = 9 Quellen (p) ergeben 429 Publikationen (P)
Klasse b = 59 " ($p_1$) " 499 " ($P_1$)
Klasse c = 258 " ($p_2$) " 404 " ($P_2$)

sowie durchschnittliche Anzahl der Aufsätze, einschließlich der Verhältniswerte:[12)]

$r = \frac{P}{p}$ für

Klasse a, $r$ = 48 und $\frac{p_1}{p} = 6{,}5$ ; $\frac{r}{r_1} = 5{,}6$ ; $n_1 = 6$
Klasse b, $r_1 = 8{,}5$
Klasse c, $r_2 = 1{,}6$ und $\frac{p_2}{p_1} = 4{,}4$ ; $\frac{r_1}{r_2} = 5{,}3$ ; $n_2 = 4{,}85$

$\bar{x}$ für $n = 6 + 4{,}85 / 2 = 5{,}4 \approx 5$.

Beispiel-Bibliographie "Lubrication" (B)

Klasse a = 8 Quellen (p) ergeben 110 Publikationen (P)
Klasse b = 29 " ($p_1$) " 133 " ($P_1$)
Klasse c = 127 " ($p_2$) " 152 " ($P_2$)

wie für das vorige Beispiel ergibt sich weiter:

Klasse a, $r$ = 13,75 und $\frac{p_1}{p_2} = 3{,}62$ ; $\frac{r}{r_1} = 3$ ; $n_1 = 3{,}3$
Klasse b, $r_1 = 4{,}58$
Klasse c, $r_2 = 1{,}19$ und $\frac{p_2}{p_1} = 4{,}37$ ; $\frac{r_1}{r_2} = 3{,}84$ ; $n_2 = 4{,}1$

$\bar{x}$ für $n = 3{,}3 + 4{,}1 / 2 = 3{,}7 \approx 4$.

12) ab hier wurde Bradford's Zahlenmaterial für Eigenberechnungen verwendet.

Der einfachste Fall soll nun sein:

$$p : p_1 : p_2 = 1 : n : n^2 \ldots$$

Nach Bradford's Beispielen:

$$n \text{ für (A)} = 1 : 5 : 5^2 = 1 : 5 : 25 \quad \text{und}$$

$$n \text{ für (B)} = 1 : 4 : 4^2 = 1 : 4 : 16.$$

Dies bedeutet für die praktische Arbeit:
Bei bibliographischen Recherchen muß ich nach Verlassen der ergiebigen Kernzone das 4 - 5fache Quellenaufkommen auswerten, um in der nächsten Zone die ungefähr gleiche Anzahl von Nachweisen wie in der ersten Zone (Kern) zu finden; bei der nächsten Zone das etwa 20fache usw.

Allgemein ausgedrückt und auf Durchschnittswerte bezogen, heißt das für

n Recall 1 : 4,5 : 20 : 90 : 410 bei n = 4,5.

(Recall = durch ein System unterstütze Rückgewinnung von Informationen)

Die recall-Werte (rW) sind im Durchschnitt ($\bar{x}$) nach den Beispielen (A) und (B) von Bradford:

Klasse a-c: rW(A) = 110 + 133 + 152/3 = 132 und
Klasse a-c: rW(B) = 429 + 499 + 404/3 = 444,
mit s = 21 bzw. s = 49 (s = Standardabweichung).
Logarithmiert man beide Reihen, so erhalten wir:

n Recall = log 1 : log 4,5 : log 20 : log 90 : log N
und rW(A) = log 429 : log 499 : log 404
und rW(B) = log 110 : log 133 : log 152.

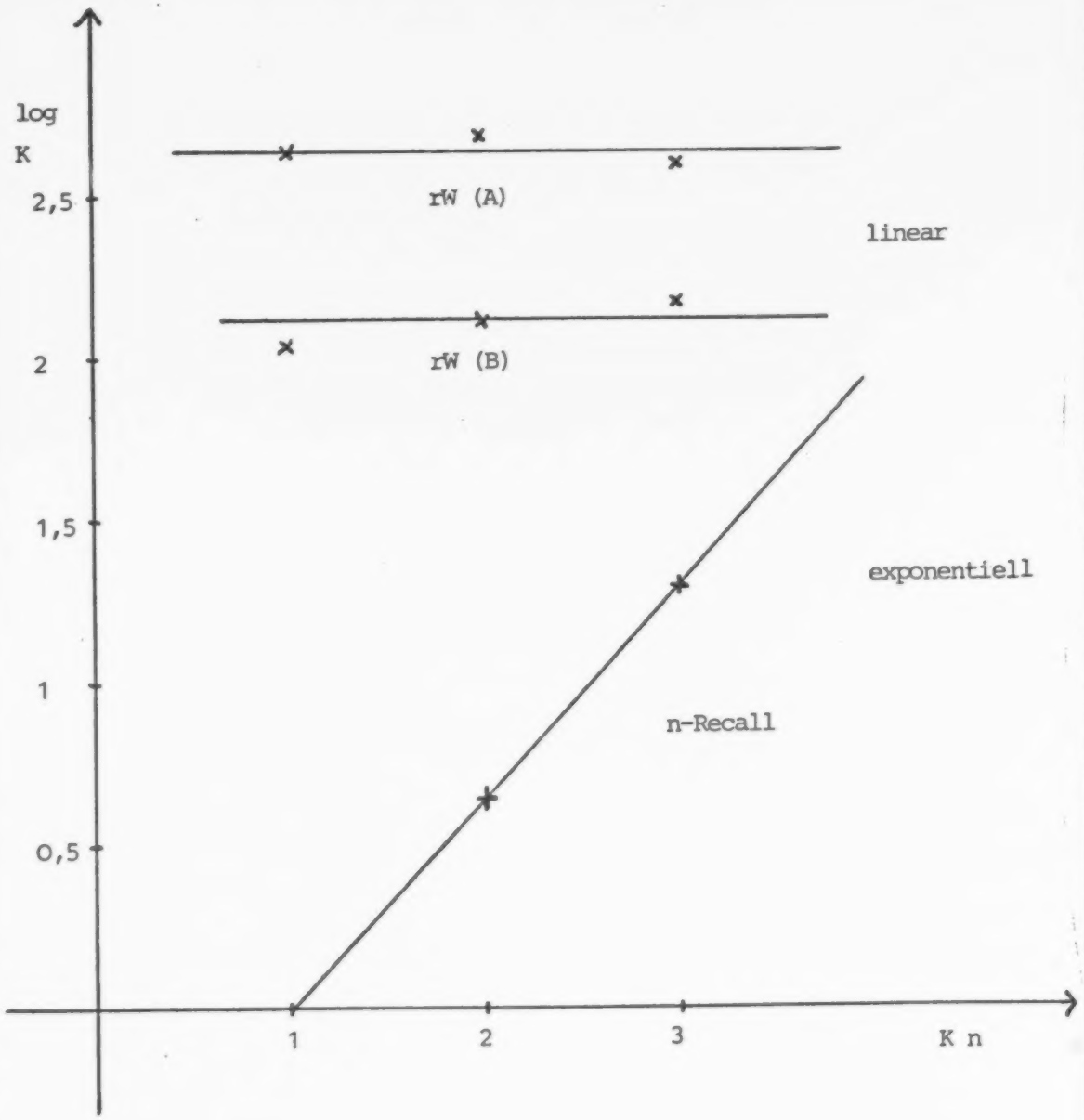
Als Ergebnis-Matrix dargestellt:

| Wertgruppen | log nach Klassen K | | |
|---|---|---|---|
| | K1 | K2 | K3 |
| n Recall | 0,00 | 0,65 | 1,30 |
| rW (A) | 2,63 | 2,69 | 2,60 |
| rW (B) | 2,04 | 2,12 | 2,18 |

Deutlich tritt nun das unterschiedliche Verhältnis n Recall/ rW zutage. Eine genauere Bestimmung mittels der Regressionsanalyse[13] zeigt: rW(A) 1. R. = 2,67 und $\hat{x} = 0$; rW(B) = 1,97 - 0,000000048 $\hat{x}$. Dies ergibt ein nahezu statisch fixiertes lineares Verhalten.

Graphisch dargestellt: (siehe nächste Seite)

13) bei Klassenerhöhung um $10^1$




Die einfache Prüfung mit Lineal ergibt deutlich die exponentielle Zunahme von n-Recall sowie das lineare von rW(A) und rW(B). Das exponentielle Wachstum von n-Recall ist angenähert wiederzugeben durch die Verdoppelung der Exponential-Werte:

$$\text{Dn-R} = 10^{0,65} = 4,5$$
$$10^{1,30} = 20,0$$
$$10^{2,60} = 398$$

(vgl. n-Recall mit n › 4,5).

Zusammenfassung:

Dieser Beitrag versucht nach der endgültigen Fassung von 1948 eine Übersicht zur Lage der Primär- und Sekundärinformation aus der Sicht von Bradford zu geben. Erst vor diesem Hintergrund und der grundlegenden Schlußfolgerung, daß ca. 60 % sog. "nützlicher" wissenschaftlicher Publikationen nicht ausgewertet und durch Informationsdienste zusammengefaßt und retrievalmäßig aufbereitet werden, ist die Problematik der Streuung von Informationen für Bradford evident.

Er kommt zu dem Umkehrschluß, daß ca. 1/3 (ausgehend von den obigen 60 %) aller wichtigen Informationen zu einer Fachfrage in den Kernzeitschriften abgehandelt werden. Diese Population von Quellen wird auch bevorzugt von IuD-Diensten ausgewertet. Da eine vollständige Erfassung jedoch anzustreben sei, muß genau untersucht werden, in welcher Weise die "übrigen" Quellen noch zu dem Fundus an relevanten, recherchierbaren Informationen beitragen.

Eine genaue Nachprüfung seiner Streuungsregel ergibt eine indirekte Relation von Kern zu nächsten Zonen wie etwa $1 : 4,5 : 4,5^2$. Die Gedankengänge Bradford's, die zu diesem Ergebnis führen, werden ausführlich dokumentiert.

# 3. Anwendung der Regel im Bibliotheks-, Informations- und Dokumentationsbereich

## 3.1 Bestandsaufbau / Erwerbung

Vorbemerkung:

Zu Beginn dieses Kapitels ist es erforderlich, den Begriff der Anwendung näher zu erläutern. Im BID-Bereich wurde das "Law of Scattering" nur in experimentellen Untersuchungen wirklich praktisch angewendet. Der größere Teil der Wissenschaftler beschäftigte sich mit der theoretischen Seite der Regel. Aus der Literatur ist keine von Praktikern durchgeführte Anwendung in Einrichtungen des BID-Bereichs zu finden, obwohl gerade für diesen Bereich Anwendungsmöglichkeiten häufig angeregt und befürwortet werden. Somit können im folgenden Kapitel nur Anwendungen im Rahmen von Forschungsprojekten aufgeführt werden. Von diesen ist besonders die graphische Methode für die Praxis sehr gut anwendbar. Dies wird von Wilkinson (1972, S. 199)[14] betont.

Für Bibliotheken ergibt sich die umfassende Bedeutung der Anwendung der Bradford'schen Regel daraus, daß sie sich nicht nur auf Zeitschriften, sondern auch auf Monographien und andere Arten wissenschaftlich-technischer Veröffentlichungen bezieht. Sie erlaubt, den Bestandsaufbau von Bibliotheken unter Berücksichtigung verschiedener Stufen der Befriedigung von Leserbedürfnissen zu untersuchen. An der Bibliothek einer medizinischen Lehranstalt zeigte sich, daß mit einem Bestand von etwa 70.000 - 90.000 Bänden die Leserwünsche zu 90-95% befriedigt werden können. Für eine 100%-ige Befriedigung der Leserbedürfnisse wäre allerding ein Bestand von 0,4 - 0,5 Millionen Bänden erforderlich, d.h. eine Ausweitung der Bestände um das 5-fache.

14) Wilkinson, E. A.: The Ambiguity of Bradford's Law
J. of docum. 28(1972)2, pp. 122-130

Um die Leserbedürfnisse möglichst optimal zu befriedigen, ist die Kenntnis unterschiedlicher Tendenzen in der Entwicklung der Forschung oder in einzelnen Zweigen der Wissenschaft nötig. Auch diese kann mit Hilfe der Streuungsregel aufgedeckt werden[15].

Nach W. Goffman und T. G. Morris (1970) könnte sogar die Erwerbungspolitik mit Hilfe der Bradford'schen Streuungsregel formuliert werden. Da für die Erwerbungspolitik wichtig ist, die Auswahl der anzuschaffenden Zeitschriften auf die zu erwartende Nachfrage abzustellen, kann eine vorherige mathematische Berechnung nach dem "Law of Scattering" sehr hilfreich sein. Die genaue Berechnung wurde bei einer Untersuchung an der Allen Memorial Medical Library, Cleveland, Ohio im Jahre 1968 durchgeführt.

Durch diese Berechnung kann der Mindestbestand (Kernbestand) von Zeitschriften bestimmt werden, welcher zum Bestand einer Bibliothek gehören muß. Dieser Kernbestand sollte aus den Kernzeitschriften plus den wichtigsten Kernzeitschriften, welche die Themen behandeln, die den Kern der Benutzer interessiert, bestehen. Soweit es der Etat erlaubt, können Zeitschriften, die nicht zum Kerngebiet gehören, auch in den Bestand aufgenommen werden. Zum "Kernbestand" und Benutzer folgende Tabelle[16]:

Minimal Nucleus of Users For March 1968

| Zone | Circulation | No. of Users | Bradford Constant (n) |
|---|---|---|---|
| 1 | 118 | 13 | — |
| 2 | 108 | 18 | 1.4 |
| 3 | 107 | 24 | 1.3 |
| 4 | 109 | 31 | 1.3 |
| 5 | 109 | 40 | 1.3 |
| 6 | 108 | 54 | 1.4 |
| 7 | 108 | 105 | 1.9 |
| 8 | 109 | 109 | 1.1 |
| | 876 | 394 | Average 1.4 |

15) Michajlov, A.J.; Cernyj, A.I.; Giljarevskiy, R.S.: Informatik 1 : Grundlagen. - Berlin: Staatsverl. der Deutschen Demokrat. Republik

16) Goffman, W.; Morris, Th.G.: Bradford's law applied to the maintenance of library collections.
in: Introduction to information sciences. - New York, 1970

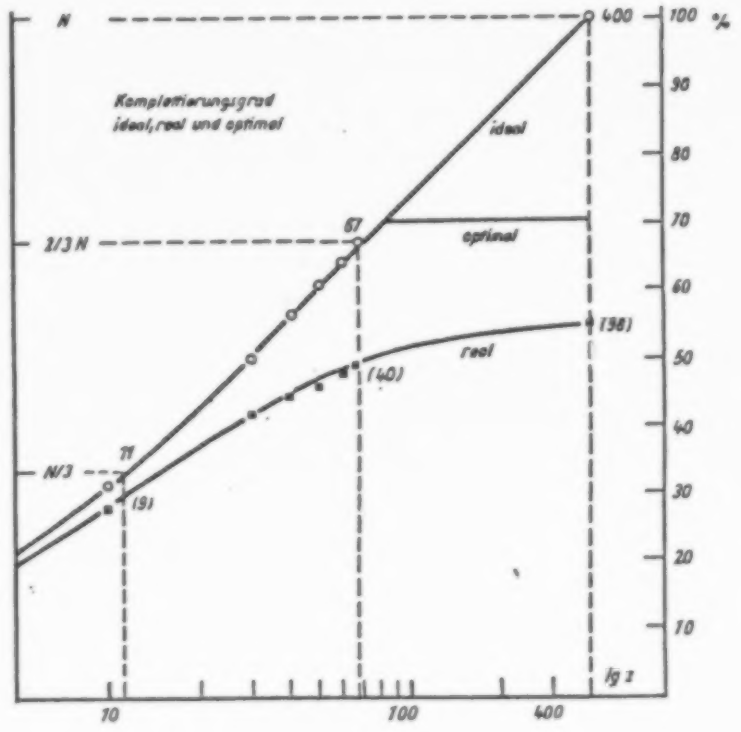
Auch G. Alabi (1979) stellt Möglichkeiten dar, mit Hilfe der Bradford'schen Regel Zeitschriften auszusondern, welche weniger benutzt werden und somit auch für die künftige Erwerbungspolitik wichtig sind: Berechnung der Kernzeitschriften anhand der Frequentierung durch Benutzer[17)]

M. Bonitz (1979) untersuchte die Optimierung des Zeitschriftenbestandes. Die Kurve der idealen Komplettierung: der Komplettierungsgrad beträgt 100% für 400 Zeitschriften.
Die Kurve der realen Komplettierung: die Information aus den tatsächlich vorhandenen (98) Zeitschriften werden aufsummiert; es wird nur ein Komplettierungsgrad von 55% erreicht, da die 98 ausgewerteten Zeitschriften nicht einmal die 98 wichtigsten gemäß einer vorgegebenen Rangverteilung sind.
Die Kurve der optimalen Komplettierung: die Zeitschriften werden so umverteilt, daß die optimale Kurve anfangs mit der idealen Kurve identisch ist, dann aber nicht weiter ansteigt, da auf die Ballastzeitschriften vollständig verzichtet wird. Es wird ein Komplettierungsgrad von 70% erreicht. [18)]

(siehe Abb. folgende Seite)

17) Alabi, G.: Bradford's law and its application
Int. libr. rev. 11(1979)1, pp. 151-158

18)




18) Bonitz, M: Wissenschaftliche Forschung und wissenschaftliche Information. - Berlin, 1979. - S. 127-139

## 3.2 Rechercheberechnung und Auswertung von Primärquellen

Wie vielfältig das "Law of Scattering" anwendbar ist, zeigt die Möglichkeit, vor der Durchführung einer Recherche das Ergebnis so gut wie möglich zu berechnen. Ebenso kann man nach der Recherche prüfen, wie gut sie durchgeführt wurde, indem das vorhergesagte Ergebnis mit dem aktuellen Ergebnis verglichen wird.
In einem Fall konnte eine 100%-ige Übereinstimmung erzielt werden (s. Tabelle unten).

| JOURNAL RANK | ARTICLES FROM JOURNAL | CUMULATIVE ARTICLES | CUMULATIVE PERCENTAGE OF ARTICLES |
|---|---|---|---|
| 1 | 37 | 37 | 13% |
| 2 | 25 | 62 | 22 |
| 3 | 14 | 76 | 27 |
| 4 | 12 | 89 | 32 |
| 5 | 12 | 101 | 36 |
| 6 | 8 | 109 | 39 |
| 7 | 7 | 116 | 41 |
| 8 | 6 | 122 | 44 |
| 9 | 6 | 128 | 46 |
| 10 | 5 | 133 | 48 |
| 11 | 5 | 138 | 50 |
| 12 | 5 | 143 | 52 |
| 13 | 5 | 148 | 53 |
| 14 | 4 | 152 | 55 |
| 15 | 4 | 156 | 56 |
| 16 | 4 | 160 | 58 |
| 17 | 4 | 164 | 59 |
| 18 | 3 | 167 | 60 |
| 19 | 3 | 170 | 61 |
| 20 | 3 | 173 | 62 |
| 21 | 3 | 176 | 63 |
| 22 | 3 | 179 | 64 |
| 23 | 3 | 182 | 65 |
| 24 | 3 | 185 | 66 |
| 25 | 3 | 188 | 67 |
| 26 | 3 | 191 | 68 |
| 27 thru 41 | 2 (15 × 2) | 221 | 80 |
| 42 thru 97 | 1 (56 × 1) | 277 | 100 |

*The results of a search in terms of articles per journal*

Die Tabelle zeigt, daß die Anzahl der Artikel in einer Zeitschrift mit abnehmendem Rang erheblich sinkt, so daß

für eine 100%-ige Erfassung der 277 Artikel verhältnismässig mehr Zeitschriften ausgewertet werden müssen als für ein niedrigeres Ergebnis. Bemerkenswert ist, daß für die Erfassung von 50% der gesamten Artikel nur 11 Zeitschriften benötigt werden, das sind 11% der Gesamtzahl der Zeitschriften.[19]

Es ist für eine Bibliothek oder ein Fachinformationszentrum, selbst bei der Spezialisierung auf wenige Wissenschaftsgebiete, fast unmöglich, alle erschienenen Artikel zu referieren. Dieses wäre nur bei einer sehr starken Zentralisierung möglich. Um aber die wichtigsten Artikel auszuwerten, können nach der Bradford'schen Regel die Kernzeitschriften ermittelt und ausgewertet werden. Fällt die Bearbeitung anderer Zeitschriften noch an, so können die Kernzeitschriften mit Priorität bearbeitet werden.

20)

*Verteilung von Arbeiten auf verschiedene Zweige der Wissenschaft, Technik und Produktion*

| Zweig der Wissenschaft, Technik oder Produktion | Zahl der untersuchten Arbeiten | Zahl der Periodika, die die Arbeiten enthalten | | | |
|---|---|---|---|---|---|
| | | 25% | 50% | 75% | 100% |
| Chemie | 3633 | 2 | 7 | 24 | 247 |
| | 1085 | 2 | 5 | 19 | 131 |
| Chemie und chemische Technologie | 187911 | 50 | 250 | 1000 | 10850 |
| Chemische Technologie | 21728 | 3 | 23 | — | — |
| Biochemie | 17198 | 3 | 12 | 56 | 851 |
| Physik | 1279 | 1 | 3 | 17 | 134 |
| | 20287 | 7 | 19 | 47 | 405 |
| Angewandte Geophysik | 1332 | 5 | 27 | 85 | 326 |
| Operationsforschung | 1763 | 3 | 18 | 67 | 370 |
| Methodologie der Statistik | 1465 | 2 | 7 | 18 | 164 |
| Elektrotechnik | 17991 | 3 | 9 | 39 | — |
| Rundfunktechnik | 1506 | 2 | 8 | 20 | — |
| Erdölindustrie | 903 | 5 | 15 | 69 | 197 |
| Schmierung | 164 | 7 | 22 | 62 | 395 |
| Geschichte der USA | 452 | 14 | 54 | 149 | 259 |

19) Drott, M. C.; Mancall, J. C.; Griffith, B. C.: Bradford's law and libraries
ASLIB proc. 31(1979)6, pp. 296-304

20) Winde, B.: Methoden u. Probl. der wiss.-techn. Information in: Information, Schlüssel zum Wissen. - Leipzig, 1972

Die folgende Tabelle faßt einige Untersuchungsergebnisse zusammen. Sie zeigt eine relativ geringe Streuung in den theoretisch orientierten Naturwissenschaften und eine stärkere Streuung bei technischen und praxisnahen Artikeln. 20)

| Disziplin | Zahl der Periodika, die enthalten 25 % | 50 % ≈ 75 % | 100 % | d. unters. Artikel |
|---|---|---|---|---|
| Chemie und Chemietechnik | 50 | 250 | 1 000 | 10 850 | 187 911 |
| Biochemie | 3 | 12 | 56 | 851 | 21 728 |
| Physik | 7 | 19 | 47 | 405 | 20 287 |
| Angew. Geophysik | 5 | 27 | 85 | 326 | 1 332 |
| Operations-forschung | 3 | 18 | 67 | 370 | 1 763 |
| Elektrotechnik | 3 | 9 | 39 | | 17 991 |
| Elektronik | 2 | 8 | 20 | | 1 506 |
| Erdölindustrie | 5 | 15 | 69 | 197 | 903 |
| Schmiertechnik | 7 | 22 | 62 | 395 | 164 |
| Atomenergie | – | – | 272 | 1 706 | 1 978 |

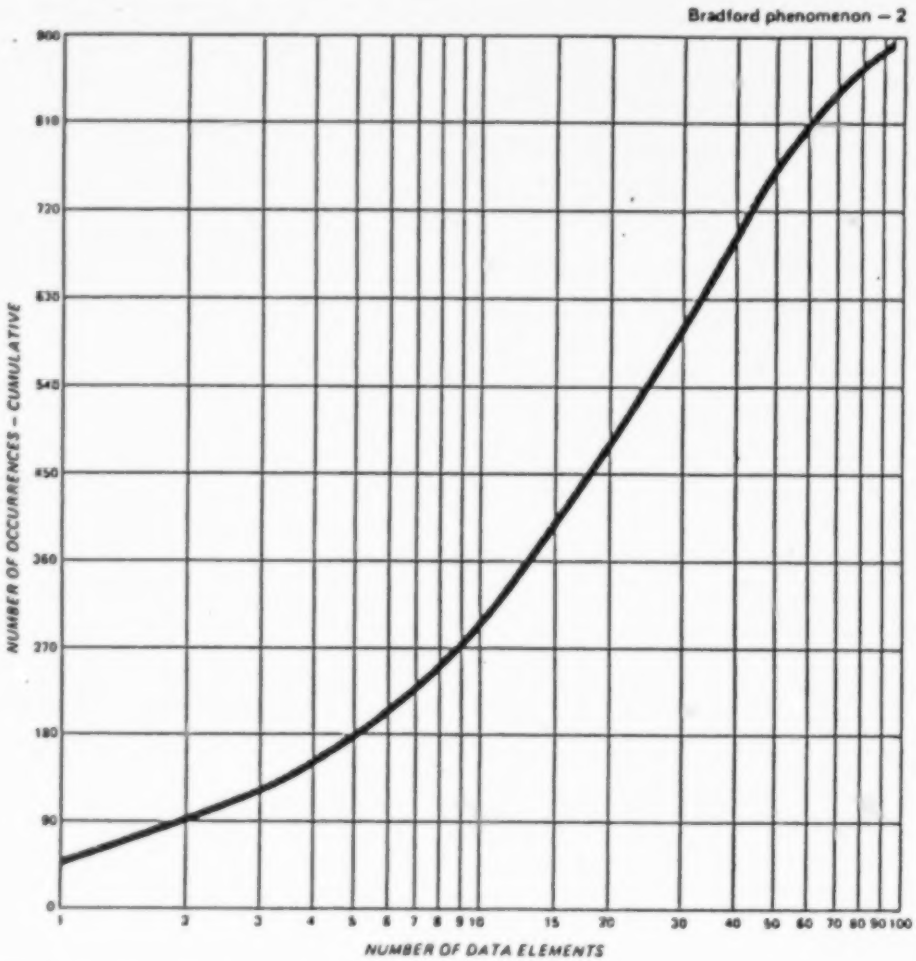
## 3.3 EDV

Für die Erstellung von Standardisierungsschemata, Austauschformaten und Suchsystemen kann die Vorhersage (Berechnung) des Bradford-Modells verwendet werden. Anhand des Modells werden die Kerndatenelemente ermittelt, welche in jedem Standardschema vorkommen müssen.
Während einer Studie über die Dokumentation der Organisationen des Systems der United Nations wurde das Auftreten von verschiedenen Datenelementen in unterschiedlichen Indices und Bibliographien untersucht. Die Indices und Bibliographien wurden von den 15 "intergovernmental organizations" verfaßt. Es wurden 95 verschiedene bibliographische Datenelemente in 67 Listen für 32 unterschiedliche bibliographische Hilfsmittel verwendet. Ihre Anwendung folgte der Bradford'schen Verteilungsregel. [21]
Hierzu nachstehende Graphik und Tabelle:

Zone distribution of data elements.

| | No. of Items (Data Elements) | Actual Number of Occurrences (Cumulative) | Predicted Number of Occurrences (Cumulative) |
|---|---|---|---|
| 1st Zone | $8 = (8 \times 1)$ | 254 | 200 |
| 2nd Zone | $15 = (8 \times 1.93)$ | 401 | 400 |
| 3rd Zone | $30 = (8 \times 1.93^2)$ | 604 | 600 |
| 4th Zone | $58 = (8 \times 1.93^3)$ | 803 | 800 |

21) Marulli, L; Koenig, M. E. D.: Bradford distribution of data elements
J. of the ASIS 30(1979)2. pp. 107-108




Number of data elements versus total number of occurrences of these elements.

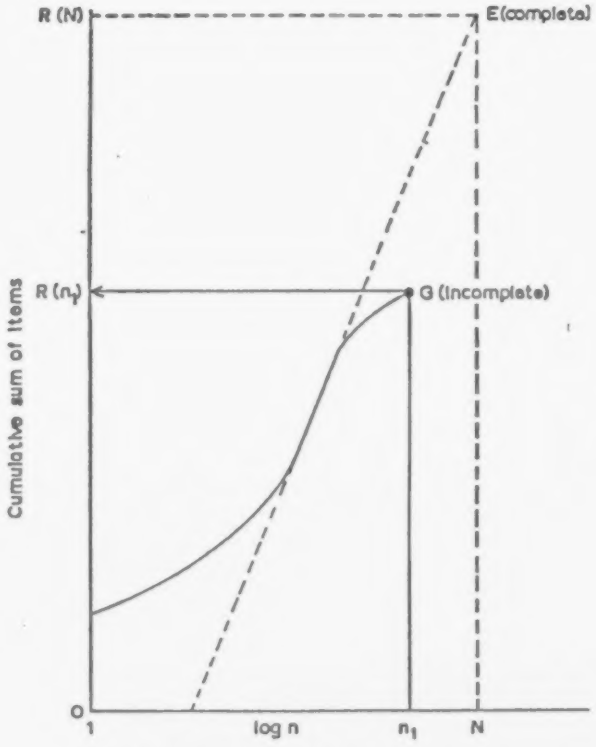
## 3.4 Ausleihe

Eine Studie der Ausleih-Nachfragen aller Krankenhausbibliotheken, welche 1975 in Zentral- und West-Massachusetts von Morton durchgeführt wurde, zeigte, daß 4368 Artikel, welche in 1071 verschiedenen Zeitschriften enthalten waren, nachgefragt wurden. Die Anzahl der Nachfragen reichte von 89 für einen Titel bis zu jeweils 1 Nachfrage nach 423 Titeln. Der Graph der Daten zeigte eine geometrische Entwicklung, und die Bradford-Konstante für diese Streuung erreichte 1, 28. Der Prozentsatz aller Nachfragen, welche das Alter der nachgefragten Ausgaben betraf, variierte von 62,48% für nicht über 5 Jahre alte Artikel und 78,15% für nicht über 10 Jahre alte Artikel bis 95,57% für Material, welches nicht älter als 30 Jahre ist.[22)]

22) Morton, D. J.: Analysis of interlibrary requests by hospital libraries for photocopied journal articles Bull. of the Med. Libr. Assoc. 65(1977)4, pp. 425-430

## 3.5 Bibliographien

Keine konventionell erstellte Bibliographie kann vollständig sein, da der Bibliograph immer zum Selektieren gezwungen ist. Die Abbildung verdeutlicht, daß man die zu erwartende Anzahl an Titelaufnahmen (E) abschätzen kann, wenn die Anzahl der auszuwertenden Quellen (N) bekannt ist. Da man absolute Vollständigkeit beim Erstellen einer Bibliographie in der Realität nie erreichen kann, entsteht stets eine Kluft zwischen der tatsächlich erreichten (unvollständigen) Anzahl an Titelaufnahmen (G) und der in der Theorie möglichen (vollständigen) Zahl.[23] (vgl. Abb. unten)

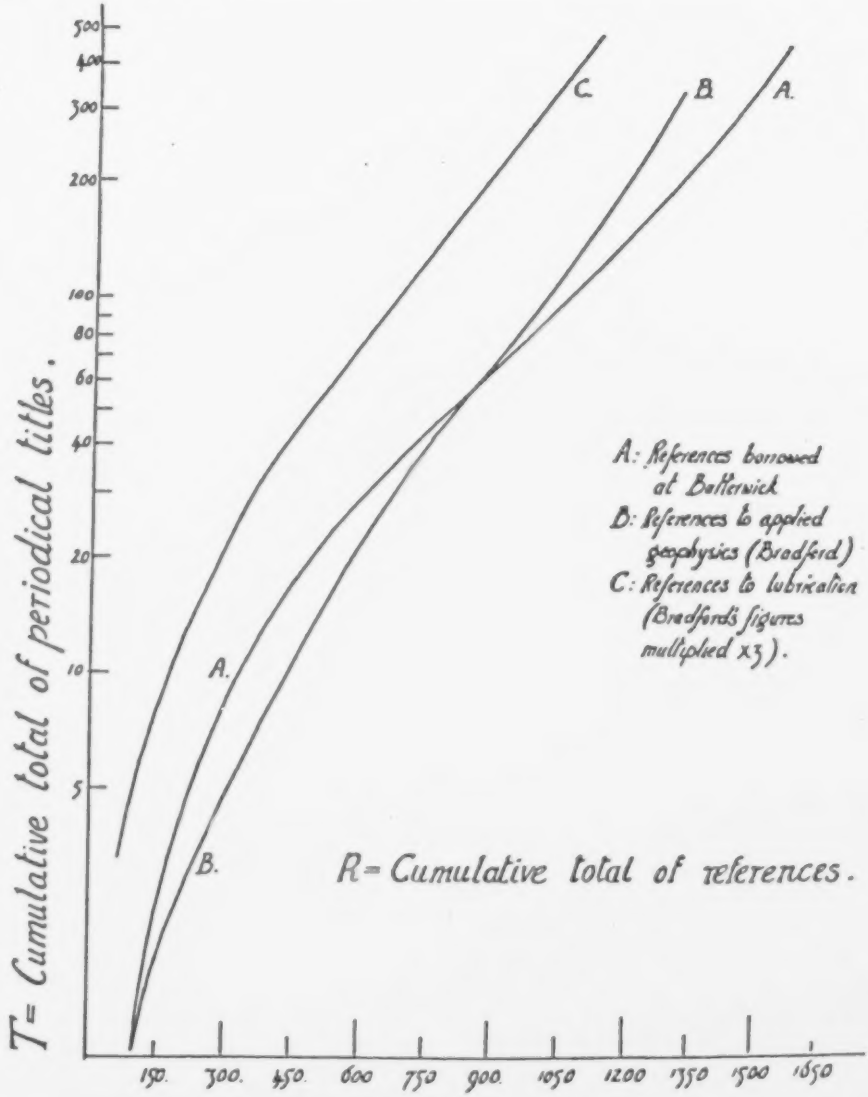



The 'Droop': An Indication of Incompleteness

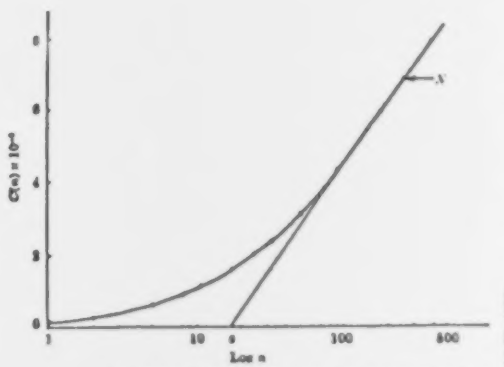
23) Brookes, B. C.: Numerical methods of bibliographic analysis
Libr. trends 22(1973)1, pp. 18-43

Vickery (1948) analysierte 1600 Zeitschriftenreferenzen, welche von der Bibliothek der Butterwick Research Laboratories ausgeliehen wurden. Das Ergebnis verglich er mit den Studien von Zeitschriftenartikeln, die von der Science Library durchgeführt wurden. Ein Mißverständnis bei der von Bradford und seinen Mitarbeitern erstellten algebraischen Analyse wurde aufgedeckt (vgl. Vickery, 1948, pp. 199), aber auch andere Sachverhalte von Interesse wurden berücksichtigt.

Die Zeitschriften stammen aus dem Fachgebiet der Geophysik, so daß ein Vergleich mit Bradford's Daten möglich war (vgl. Abb. unten).[24)]



In Spezialbibliotheken wurden Bibliographien bisher nicht auf ihre Vollständigkeit geprüft. Hiermit ist die sorgfältige Durchsicht der Bibliographie von einem Fachreferenten gemeint. Für ein Fachgebiet ist es lediglich notwendig, die Produktivität der Kernzeitschriften festzustellen, um die Vollständigkeit der Bibliographie zu schätzen. Brookes stellte mit Hilfe der Bradford'schen Regel fest, daß man um die Hälfte der insgesamt 2000 in der Bibliographie "Physics of fluids" enthaltenen Zeitschriften nur die 100 produktivsten untersuchen muß, um den Kernbereich festzulegen.
Die nachfolgende Graphik zeigt eine Abweichung vom "Bradford-Zipf-Graphen". Hier zeigt es sich, daß Zitate nicht bibliographisch gleichförmig sind. Die Abweichung resultiert daraus, daß Zeitschriften, welche in die Klassifikation "Physics of fluids" eingeordnet wurden, zu Randgebieten wie Mathematik und Elektronik gehören. Ist das Fachgebiet zu dem eine Bibliographie erstellt werden soll eng ("exakt") definiert, stimmt der Graph mit dem von Bradford überein (s. Abb.)[25]

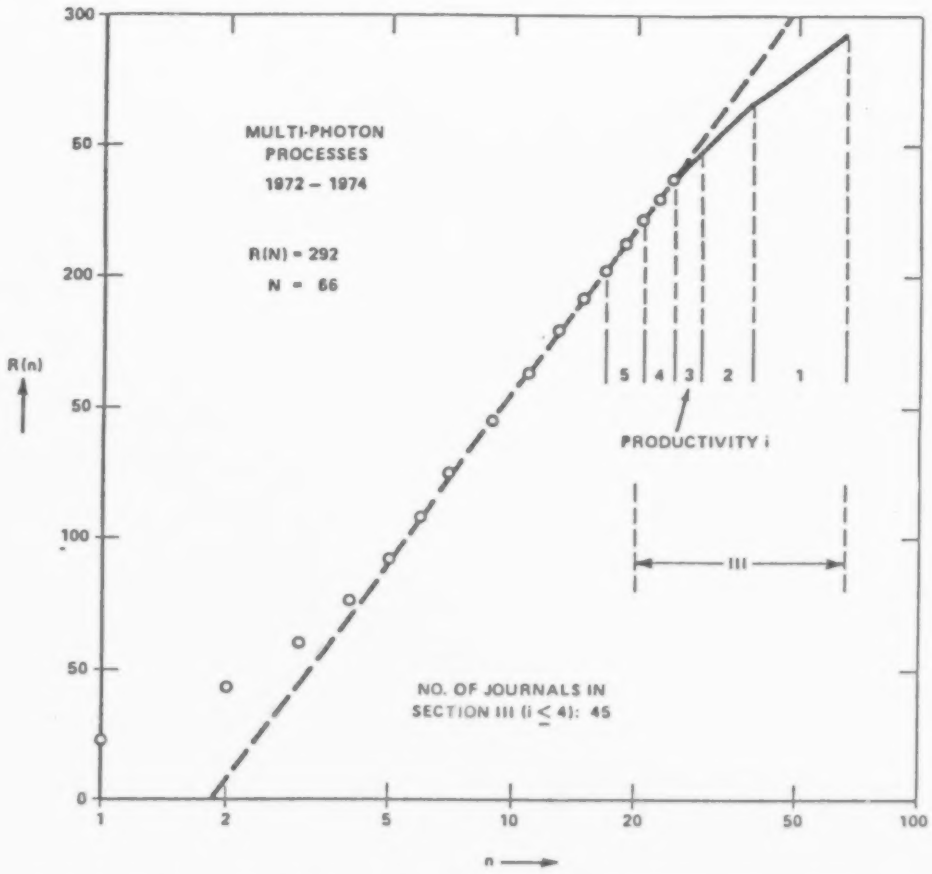



BIBLIOGRAPH OF CITATIONS IN *PHYSICS OF FLUIDS* (EAST AND WEYMAN): THE END-POINT DOES NOT CONFORM; $N = 248$, $E = 372$.

24) Vickery, B. C.: Bradford's law of scattering
J. of docum. (1948)4, pp. 198-203

25) Brookes, B. C.: Bradford's law and the bibliography of science
Nat. 244(Dec. 1969) pp. 953-955

Für die nachfolgende Graphik wurde eine Bibliographie bezüglich "multi-photon processes" mit dem Berichtszeitraum 1972 - 1974 ausgewertet. In insgesamt 66 Zeitschriften wurden 292 relevante Artikel gefunden. Die 3 Zonen unterschiedlicher Ergiebigkeit lassen sich weiter unterteilen in Unterzonen, mit deren Hilfe man genauere Vorhersagen für den weiteren Verlauf der Kurve treffen kann.[26)]




Bradford distribution of a bibliography on multiphoton processes in atomic, molecular, and solid-state physics.

26) Praunlich, P.; Kroll, M.: Bradford's Distribution : a new formulation
J. of The ASIS 29(1978)2, pp. 51-55

Wie die Beispiele gezeigt haben, ist die Bradford-Regel vielseitig praktisch einsetzbar. Meist werden Verteilungen von Informationen im Bereich der Print-Medien untersucht und interpretiert. Daß auch für das aktuelle Online-Retrieval-Management die Bradford'sche Technik von Nutzen ist, wird überzeugend durch die Arbeit von Tenopir (1982) nachgewiesen. Gleichzeitig bietet diese Arbeit einen übersichtlichen Einstieg in die Bradford-Problematik. Aus diesen Gründen ist die Publikation "Distribution of citations in databases in a multidisciplinary field" komplett wiedergegeben.[27)]

27) Tenopir, C.: Distribution of citations in databases in a multidisciplinary field
Online rev. 6(1982)5, pp. 399-415

ONLINE REVIEW

# Distribution of citations in databases in a multidisciplinary field

*Carol Tenopir*

**Abstract:** Word-oriented databases of potential relevance to the multidisciplinary field of emergency management were identified by the University of Illinois, Information Retrieval Research Laboratory under contract to the United States Federal Emergency Management Agency (FEMA). This article is an extension and outgrowth of that contract. It analyzes forty databases for relevance to emergency management by searching each database using an emergency management subject profile, printing a random sample of citations to determine percent of false drops, and ranking the databases according to number of relevant citations. Bradford's law of scatter is shown to apply to this multidisciplinary field, using databases instead of journals and citations instead of articles. No one database provides more than 19% of the literature, however, illustrating that the literature in the field is widely scattered throughout databases. These findings can help in the choice of the specific databases containing emergency management citations and in the determination of how many databases need to be searched in order to retrieve a given percentage of the literature. A companion article in this issue of Online Review — 'Evaluation of database coverage: a comparison of two methodologies,' explains the subject profile evaluation method employed in this project and compares it to another coverage evaluation technique.

## 1. Introduction

As the number of publicly available bibliographic databases continues to grow, it becomes increasingly difficult for a searcher to select the most appropriate databases for any given search topic. The searcher faces the task not only of deciding which databases are of the most potential relevance, but also of deciding how many databases should be searched to get adequate recall of citations.

Recent studies have emphasized the growing realization of the necessity of searching multiple databases and the increasing frustration in choosing appropriate databases. Robert Niehoff, Stan Kwasny, and Michael Wessells of Battelle's Columbus Laboratories summarized this situation in their article that addressed the related problem of vocabulary incompatibilities among databases:

*The author is at the Hamilton Library, 2550 The Mall, University of Hawaii at Manoa, Honolulu, Hawaii 96822 (from September 1st 1982).* *Paper received May 1982.*

## About the author

**Carol Tenopir**

Carol Tenopir is Library Systems Librarian at the University of Hawaii at Manoa and a doctoral student at the University of Illinois at Urbana-Champaign. During the 1981/1982 Academic year she was employed at the Information Retrieval Research Laboratory, Coordinated Science Laboratory, University of Illinois. Formerly, she was Vice-President of Operations for Cibbarelli and Associates, an information consulting firm.

There is growing evidence to suggest that online users perform a significant percentage of searches with multiple databases. Recent articles in the literature emphasize the fact that no single database contains all the relevant literature on a given topic. Users must recognize that perhaps only sixty to seventy percent of the relevant literature on a given topic will be retrievable from a single database, and then only if the "right' database was chosen [1].

This problem is especially difficult for searches in multidisciplinary subjects where there are no subject specialty databases from which to choose. Choosing the 'right' database becomes a formidable task when databases from all subject disciplines must be considered. A search in a multidisciplinary field could potentially involve dozens, or perhaps hundreds, of databases, no one of which could be expected to contain anywhere near sixty to seventy percent of the relevant literature.

Some limits on the number of databases searched on any given topic are obviously necessary. Also needed is some guidance on what specific databases potentially contain the most information of relevance in a given subject area. Choice of databases of most potential relevance to a subject is by definition specific to (and different for) each subject area. Estimates of the number of databases that should be searched may be generalizable, however.

Niehoff, Kwasny, and Wessells did not directly address the problem, but they suggested a solution. The sixty to seventy percent figure, mentioned above, "is nothing more than a manifestation of Bradford's law of scatter at the database level instead of the journal level." [1] If it can be demonstrated that database coverage of the literature on a complex multidisciplinary subject is indeed merely a manifestation of Bradford's law, guidelines for the number of databases that would need to be searched to obtain a given percentage of the literature could be established.

This article will examine database coverage in the field of emergency management. It will test if Bradford's law applies to citations in databases in a multidisciplinary field and identify the databases that contain the most citations relevant to

emergency management. The report is an extension of a project undertaken for the Federal Emergency Management Agency to create a model Directory of Databases relevant to emergency management [2].

## 2. Definitions

*Bradford's law*

In 1948, Samuel C. Bradford first published his theory that has become known as Bradford's law of scatter or Bradford's distribution. [3] Bradford applied his ideas to articles in journals in narrow subject areas. Many explanations, elaborations, interpretations, and applications of this law have been published since then that extend its predictive powers to other areas of interest to information specialists.

Simply stated, Bradford's law says that there is a quantitative relation between journals and the articles published in them. It shows that a large percentage of the articles in a narrow subject area are contained in a small percentage of the journals. The so-called 'verbal' or theoretical formulation of this law (as opposed to the 'graphical' or observational formulation) states:

> If scientific journals are arranged in order of decreasing productivity of articles on a given subject, they may be divided into a nucleus of periodicals more particularly devoted to the subject, and several groups or zones containing the same number of articles as the nucleus, where the number of periodicals in the nucleus and succeeding zones will be $1:a:a^2$. . . [3].

M. Carl Drott has restated Bradford's explanation.

> He [Bradford] examined all of the journal titles contributing to a bibliography on applied geophysics. Bradford discovered that he could divide the titles into three groups, such that each group of titles contributed about the same number of articles. Starting with the titles which contributed the most articles, he divided the articles into three roughly equal groups:
> The first 9 titles contributed 429 articles.
> The next 59 titles contributed 499 articles.
> The last 258 titles contributed 404 articles.
> The value of this arrangement lies in the number of titles it takes for each one-third of the articles. In this case, Bradford discovered a regularity in calculating the number of titles in each of three groups:
> 9 titles
> $9 \times 5$ titles (equals 45 titles)
> $9 \times 5 \times 5$ titles (equals 225 titles) [4]

This can also be written $9 : 9 \times 5 : 9 \times 5^4$ or, because the size of the core and the multiplier might be different in each case, $1 : a : a^2$.

Unfortunately, Bradford's theoretical expression of the verbal formulation did not precisely mathematically agree with his experimental results or the graphical representation. Discussions of these differences and how they have been resolved over the years can be found in Wilkinson, [5] Cline, [6] Vickery, [7] and Brookes [8]. Detailed consideration of these differences is beyond the scope of this paper.

*"Bradford's law can be expected to also be of practical help in deciding how many databases are necessary to be searched in a multidisciplinary field"*

A commonly agreed upon formulation for testing for a Bradford distribution has been adopted in this paper [4]. This formula is given as:

$$R(n) = k\log(n)$$

where:

R(n) = cumulative total of relevant citations found in the first n databases when all databases are ranked 1,2,3 . . .n in order of decreasing productivity

n = cumulative number of databases producing R(n) relevant conditions

k = constant.

Graphical representation is normally drawn on semi-log paper as shown in Fig. 1. Note the deviation from linearity at each end of the plot. These deviations are typical of Bradford plots for journal literature. When there is no deviation from linearity the plot is sometimes referred to as a Zipf distribution [9].

Although the accepted method of testing Bradford's law is to test articles in journals in a narrow scientific subject, Cline demonstrated it applied to citations in journals in the interdisciplinary field of library science [6]. Bradford's law has also been shown to apply to the items borrowed from a library, the users of a library, contributors to a discussion at a conference, the index terms assigned to documents, and the publication of books by publishers. In fact, B.C. Brookes believes that:

> Bradford's law expresses a very general characteristic of the *physical* aspects of human communication, of its use of the instruments — words, numbers, books, paper, telephone, traffic — which has not yet been generally recognized or exploited in the design of information systems [8].

Bradford's law has thus been shown to be of great interest in a wide variety of practical library and information situations. It can be expected to also be of practical help in deciding how many databases are necessary to be searched in a multidisciplinary field such as emergency management.

*Emergency management*

The field of emergency management is concerned with the identification, prediction, and mitigation of, the preparation for, and recovery from large-scale hazards or disasters of all types. Both natural disasters (e.g. storms, earthquakes, volcanic eruptions) and man-made or technological disasters (e.g. nuclear power plant accidents, war, toxic chemical spills) fall within the scope of emergency management.

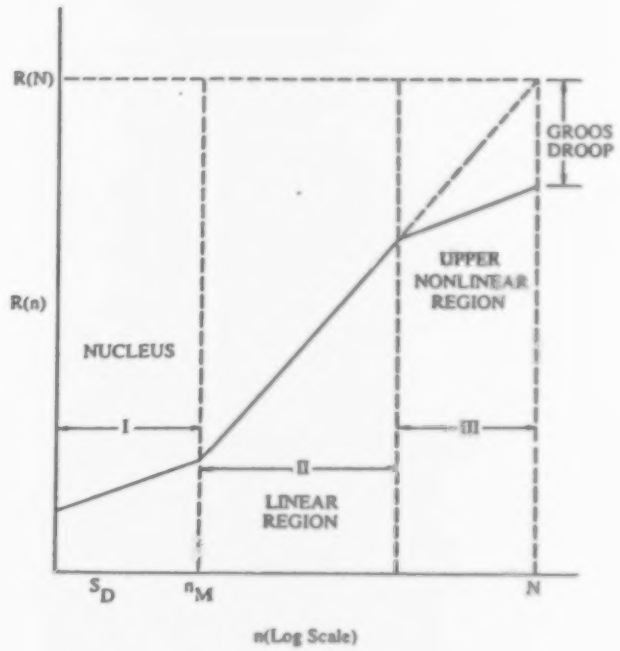



**Fig. 1.** *General forms of Bradford distribution*

*Cline, Gloria S. "Application of Bradford's Law to Citation Data." College and Research Libraries 42 (January 1981): 54.*

Many subject disciplines are incorporated in the field. Practitioners potentially have interest in information on a wide variety of topics. For example, in the design of shelters, information about sanitation, food storage, potable water, claustrophobia, etc. may be of interest whether or not it pertains specifically to emergency shelters. Studying structural collapse necessitates at times the entire literature of engineering and, perhaps, medicine. Emergency management interests include very narrow scientific subdisciplines and very broad policy or planning issues.

On the national level, the Federal Emergency Management Agency (FEMA) has emergency management as its primary charge. At the state and local levels, a number of public and private agencies are concerned with the management of all dangers to their citizens.

Emergency management interests thus embrace all disciplines and levels of expertise. Nearly every database is of potential interest. Awareness of the current literature on all aspects of emergency management is important to a wide variety of people and agencies. Bibliographic databases are important sources for awareness of this literature. Assistance in choice of the most useful of these databases and an idea of how many databases are necessary to yield a given percentage of the literature in the field would be helpful to information managers and practitioners.

### 3. Review of the literature

Recent literature reflects the growing concern with how to choose the optimum number of databases or which specific databases are best for a given topic. This concern is often tied to the growing number of multidisciplinary fields where database choice is not clear-cut and literature may be expected to be widely scattered. Several authors have addressed the issues of multiple-database searches or choice of databases.

*Choice of databases*

Choice of the specific databases that will yield the most information on a given topic was the first of these concerns to be addressed. Among the authors addressing the topic, Judith Wanger recognized the problem of selecting the most appropriate databases from among the many available. She believed "the selection of one or more databases that are appropriate for a given information problem actually begins in the analysis of the information problem itself" and that the database selection requires "several different skills and knowledge bases, including a special skill that is not quite definable, but somehow characterizes the expert searcher" [10].

Wanger went on to define principles and skills useful in learning how to select appropriate databases. These principles are based on the classification of databases into levels of potential relevance to a given search problem by four characteristics:

1. Subject/content/topic coverage
2. Source document coverage
3. Time period coverage
4. Searchable and printable data elements of the database [10].

At the time Wanger was writing the only practical ways to classify databases by these characteristics were:

1. trial and error searching
2. review of printed tools
3. take clues from assigned category or classification codes
4. rely on experience, knowledge of the databases, and special analytical skills [10].

Epstein and Angier [11] and Hawkins [12] offered advice on how to conduct successful multiple database searches. Like Wanger, they recognized the need for searching several databases and the problems associated with choosing which databases to search. Hawkins mentioned the several printed database subject guides that were then available as a way to help the choice process. He then moved on to discuss searching strategies. Epstein and Angier used a core list of journals to help choose the most comprehensive databases in psychology and psychiatry. The databases that included coverage of most of the core journals were considered to be the most relevant in the field of behavioral sciences.

*"Commercial offerings, however, do not help compare and identify databases unless they are on the same commercial system"*

Both Epstein and Angier and Hawkins emphasized the special necessity of choosing multiple databases when searching in a multidisciplinary field. Hawkins saw this as an ever increasing problem tied to the changing nature of disciplines:

> The last several years have witnessed the emergence of major interdisciplinary fields of science and technology. Examples are energy, materials science, biomedicine, and bioengineering. Traditional boundaries between scientific fields are being broken, and research is becoming more interdisciplinary . . . .
> These changes affect the world of online searching as well. As scientific research changes and broadens, searchers must use a more interdisciplinary approach to online searching. The chance that only one database will completely satisfy a search request is becoming smaller [12].

As early as 1975, Martha Williams tested an experimental 'database selector' that allowed selection of databases regardless of their vendor, but a commercially available selector has never been developed [13], [14]. Database selection has become somewhat easier in the last few years with the introduction of several cross database tools. Now all major commercial vendors (BRS in 1979, SDC in 1978, and Dialog in 1980) offer a master index database that includes indexed terms from all of their databases. These master indexes are useful in helping to locate what databases within one system have the most citations on any given term or combination of terms. These commercial offerings, however, do not help compare and identify databases unless they are on the same commercial system. Database directories by Williams [15] and by R. Cuadra [16] help in the broad intellectual decisions, but offer no real assistance in the choice of appropriate databases for specific narrow queries.

Evaluation and comparison studies of the coverage of various databases are also helpful in selecting appropriate databases for multi-file searches in a given subject area. The literature of database evaluation is too extensive to review here, but excellent reviews can be found in Diodata [17] and in Yska and Martyn [18].

*Number of databases*

Concern with selecting the correct number of databases, especially in multidisciplinary fields, is a more recent and more unusual phenomenon in the literature. Aslib published the results of two studies in the mid-1970s that were of direct pertinence to this concern.

In *Service to an Interdisciplinary Need-Group from Computerized Secondary Services*, John Martyn saw the:

> core of the problem is that the twentieth century no longer fits the disciplinary classification of the nineteenth, by which the major abstracting and indexing services are structured. As areas of study become increasingly multidisciplinary, so a growing number of groups and individuals are finding it necessary to use not one but a number of secondary services in order to collect information on their topics of interest [19].

Martyn examined five bibliographic databases ("computerized secondary services") to determine how a group of databases together met the information needs of scientists in the multidisciplinary field of biodeterioration. He found that no single service covered more than sixty percent of the total citations in the field; leading him to conclude "it is necessary to look in a number of services in order to attempt reasonably complete coverage of the topic" [19]. Martyn did not examine enough secondary services to allow him to determine what the number should be in order to retrieve a given percentage of the literature.

*Databases Suitable for Users of Environmental Information* [18] identified and assessed bibliographic databases that would meet the needs of European users of environmental information. Forty-five databases were evaluated, and the ones that contained the most citations on all aspects of environmental studies were identified.

> What is present is a first approximation to guide the user in selecting a small range of bases which have the highest probability of producing material relevant to his interest [18].

Yska and Martyn did not calculate how many of the forty-five databases would need to be searched in order to get a certain number of citations, but this can be readily calculated from their data.

A dissenting view on the issue of multiple database searching was expressed by John Edward Evans [20]. Evans questioned the widespread assumption that multiple database searches are necessary. He examined the databases used in all searches conducted at the University of South Dakota without separating them by search topic or area. Eleven databases accounted for 75.7% of the databases selected in searching; the next eleven databases added only 14.9% of the searches. Twenty-nine databases were needed to achieve 94.7% and a total of fifty-eight databases were used. Based on the results of this study, a policy was implemented to restrict the number of databases used in any given search and to emphasize first the use of the one most likely database from the 'top' eleven. Evans concluded:

> there is a relatively small number of databases that are useful in meeting the research needs of an academic search service. There is also the suggestion that the databases whose use was restricted were not entirely germane in the first place and probably should not have been used [20].

*"Demonstration of a Bradford distribution in databases would allow a calculation of the optimum number of databases to be searched to retrieve a given percentage of the literature"*

The policy decision and conclusions made from this study seem overly broad and are based on the faulty assumption that databases were not used by searchers because they were irrelevant, not because searchers were unaware of their contents. They do not bear directly on the present study, however. Evans' analysis of the number of databases and the number of citations retrieved is of direct interest to this study. In relation to the number of databases necessary to yield a given percentage of the total number of citations, Evans found:

> The analysis indicates that a single database search will retrieve, on the average, 61.0% of the information available. For many researchers this may well be sufficient. Using a second database will usually increase quantitative coverage to 88.3% and three databases, on the average, will retrieve 98% of the information available [20].

Evans' assumption — that the same number of databases in all subject areas, whether multidisciplinary or narrowly scientific, will yield the same percentage of the total literature — is questionable. His conclusions about what will satisfy researchers also seem overly generalized and somewhat naive. The attempt to compute an optimum number of databases to yield a given percent of the literature is pertinent, however, and his data suggest that Bradford's law applies to citations in databases.

*Summary of the literature*

The choice of the best and optimum number of databases in online searching is of continuing and growing concern, especially with the proliferation of multidisciplinary fields and the great increase in the number of databases. This concern is reflected in the literature. Much progress has been made in choosing the best databases for a given topic with the creation of master index files, database directories and coverage evaluations. Less progress has been made on the issue of the number of databases, although it is beginning to be studied.

The remaining sections of this paper describe the study conducted to determine if Bradford's law applies to citations in databases in the field of emergency management and to identify the databases with the most citations of relevance to emergency management. Demonstration of a Bradford distribution in databases in the multidisciplinary field of emergency management would allow a calculation of the optimum number of databases to be searched to retrieve a given percentage of the literature.

## 4. Methodology

The first step in this project was to learn exactly what the field of emergency management encompasses. This was achieved by talking to various people within the Federal Emergency Management Agency and several local disaster centers. Literature in the field was also reviewed, with special attention paid to references made to useful databases.

Because the field of emergency management includes so many subdisciplines, it was decided that every specific subject could not be comprehensively tested in this project. Instead, the most general aspects of the field were chosen for testing, in the belief that the general interests would be the most multidisciplinary in nature. The following general subjects were selected for searching:

Emergency management
Natural disasters
Man-made disasters
Technological disasters
Assistance, mitigation, operations or preparations for emergencies, disasters or hazards.

These terms were searched using the format and logical relationships appropriate to the online service being searched. Use of such broad terms may bias the study towards those databases with broad, rather than specific, indexing policies, but it was the only practical way to test the nature of the field without searching hundreds of specific subject terms.

Over 750 publicly available databases were reviewed as possible candidates for the study. The primary source for this review was the 1982 edition of *Computer Readable Databases: A Directory and Data Sourcebook* [15]. An initial list of fifty-seven candidate databases was compiled (See Appendix 1). For reasons of economy, this list was narrowed down to the forty databases judged to be of highest potential relevance and available through BRS, Dialog or SDC (See Appendix 2).

The variety of subjects represented by the final forty databases is included in Appendix 2. In addition, types of materials indexed in the databases varies considerably. Primary information types include:

journal articles
government publications
popular magazine articles
books
conference proceedings
research reports
dissertations
research in progress
audiovisual materials

Twenty-two of the databases were searched on BRS, seventeen on Dialog and one on SDC [21]. The same terms were searched in all databases in each system, although the logic and command formulation necessarily differed. A random

sample of approximately sixty citations from each database was printed to allow for relevance testing. Relevance was judged by the author to be any citation that was clearly not a false drop. Because no specific query was being tested, a more precise definition of relevance did not apply. The sixty citations allowed a percentage of false drops to be calculated at the 90% confidence level. Differences in databases' indexing policy, multi-meaning of terms in some subject areas, and variations due to different logical formulations across systems were partially compensated for by eliminating obvious false drops. The final number of emergency management related citations per database thus represents only relevant citations.

## 5. Analysis

*Choice of databases*

After the searching and relevance judgement was completed for each of the forty databases, the final number of relevant citations in each was calculated. Fig. 2 presents the databases in ranked order by number of relevant citations. This ranking can be used to select those databases that contain the highest total number of citations of interest to the broad areas of emergency management. It should be noted that the ranks could shift slightly where there are small differences among databases because the number of relevant citations in each is an estimate based on a sample.

This ranking does not take into account the wide variety in the number of years included in each database, however, so it does not give any indication of the currency of the citations or density of coverage in any database. In Fig. 3 the databases are re-ranked by the number of emergency management citations per year of coverage. When databases were split into several files, this number represents only the portion searched. Both rankings should be considered when selecting the databases that contain the most information in the field of emergency management.

*Bradford distribution*

When the total number of citations found in every database is added together, a total relevant citation pool results [22]. With this citation pool and the number of relevant citations in each database, a plot can be drawn to test for a Bradford distribution.

Fig. 4 shows the results of this plot. The straight line is the least-squares fit. The data points fit the line with a correlation coefficient of .995. The plot fits the $R(n) = k\log(n)$ formulation of Bradford's law. It can thus be seen that the linear portion of a Bradford distribution does apply to databases within the field of emergency management. However, there is not the initial rising curve or concave portion that is characteristic of the usual Bradford nucleus or core. In a typical Bradford distribution, the core deviates from the linear plot due to a higher concentration of relevant citations in the core. In the field of emergency management no deviation from the linear plot is found. This shows that the concentration of citations in the core databases is not as great as might be expected. The general linearity technically makes this curve a Zipf distribution rather than a true Bradford distribution [9].

**Fig. 2.** *Databases ranked by number of relevant citations*

| | *Database* | *Number of citations* | *Confidence interval* |
|---|---|---|---|
| 1. | DOE Energy | 6089 | ± 5.7% |
| 2. | NTIS | 4401 | ± 3.9% |
| 3. | SSIE | 4317 | ± 6.7% |
| 4. | GPO Monthly | 2460 | ± 2.0% |
| 5. | Compendex | 1852 | ± 5.5% |
| 6. | Enviroline | 1292 | ± 3.2% |
| 7. | Health Planning | 922 | ± 4.2% |
| 8. | Pollution Abstracts | 818 | ± 3.3% |
| 9. | NCJRS | 753 | ± 7.3% |
| 10. | Safety Science | 746 | population |
| 11. | ABI/Inform | 589 | ± 7.6% |
| 12. | GeoRef | 581 | ± 3.3% |
| 13. | Inspec | 568 | ± 6.0% |
| 14. | Chemical Abstracts | 559 | ± 3.7% |
| 15. | CAB Abstracts | 493 | ± 8.2% |
| 16. | Medline | 485 | ± 6.9% |
| 17. | Agricola | 425 | ± 6.4% |
| 18. | Excerpta Medica | 391 | ± 7.4% |
| 19. | Frost and Sullivan DM | 371 | ± 5.4% |
| 20. | Energyline | 362 | ± 7.4% |
| 21. | Eric | 345 | ± 7.2% |
| 22. | Aptic | 302 | ± 8.0% |
| 23. | Environmental Bib. | 221 | ± 3.7% |
| 24. | GeoArchive | 220 | ± 2.0% |
| 25. | Oceanic Abstracts | 219 | ± 7.5% |
| 26. | NCMH | 207 | ± 6.9% |
| 27. | Life Sciences | 191 | ± 8.2% |
| 28. | Met/Geo | 184 | ± 4.6% |
| 29. | Magazine Index | 154 | ± 6.8% |
| 30. | PsycInfo | 145 | ± 7.7% |
| 31. | SciSearch | 142 | ± 6.7% |
| 32. | Conference Papers | 133 | ± 6.2% |
| 33. | CRIS/USDA | 120 | ± 7.9% |
| 34. | IH State Publications | 110 | population |
| 35. | PAIS | 94 | population |
| 36. | Sociological Abstracts | 92 | ± 7.5% |
| 37. | Biosis | 68 | population |
| 38. | Comp. Dissertation | 55 | ± 6.5% |
| 39. | Population Bibliography | 8 | population |
| 40. | EIS | 1 | population |

**Fig. 3.** *Databases ranked by number of relevant citations per year of coverage*

| | *Database* | *Years of coverage* | *Number of citations* |
|---|---|---|---|
| 1. | SSIE | 5.2 | 836 |
| 2. | DOE Energy | 8.2 | 746 |
| 3. | NTIS | 7.3 | 607 |
| 4. | GPO Monthly | 5.3 | 464 |
| 5. | Compendex | 6.2 | 300 |
| 6. | Medline | 2.3 | 208 |
| 7. | Excerpta Medica | 2.4 | 162 |
| 8. | Safety Science | 5.6 | 134 |
| 9. | Enviroline | 11.3 | 115 |
| 10. | Health Planning | 8.3 | 112 |
| 11. | Inspec | 5.2 | 110 |
| 12. | Chemical Abstracts | 5.1 | 110 |
| 13. | NCJRS | 10.1 | 75 |
| 14. | Frost and Sullivan DM | 5.2 | 72 |
| 15. | Pollution Abstracts | 12.0 | 68 |
| 16. | SciSearch | 2.1 | 68 |
| 17. | Life Sciences | 3.0 | 64 |
| 18. | Agricola | 7.2 | 59 |
| 19. | ABI/Inform | 11.1 | 53 |
| 20. | CAB Abstracts | 10.2 | 49 |
| 21. | Energyline | 11.1 | 33 |
| 22. | Magazine Index | 5.3 | 29 |
| 23. | GeoArchive | 8.0 | 28 |
| 24. | GeoRef | 21.2 | 27 |
| 25. | Environmental Bib. | 8.3 | 27 |
| 26. | Aptic | 12.8 | 24 |
| 27. | Eric | 16.1 | 22 |
| 28. | Biosis | 3.3 | 21 |
| 29. | IH State Publication | 5.4 | 20 |
| 30. | Met/Geo | 10.1 | 18 |
| 31. | CRIS/USDA | 7.1 | 17 |
| 32. | NCMH | 13.0 | 16 |
| 33. | Conference Papers | 8.8 | 15 |
| 34. | Oceanic Abstracts | 18.1 | 12 |
| 35. | PsycInfo | 15.0 | 10 |
| 36. | PAIS | 10.3 | 9 |
| 37. | Sociological Abs. | 23.0 | 4 |
| 38. | Population Bib. | 16.1 | 1 |
| 39. | Comp. Dissertation | 122.2 | 1 |
| 40. | EIS | | 1 |

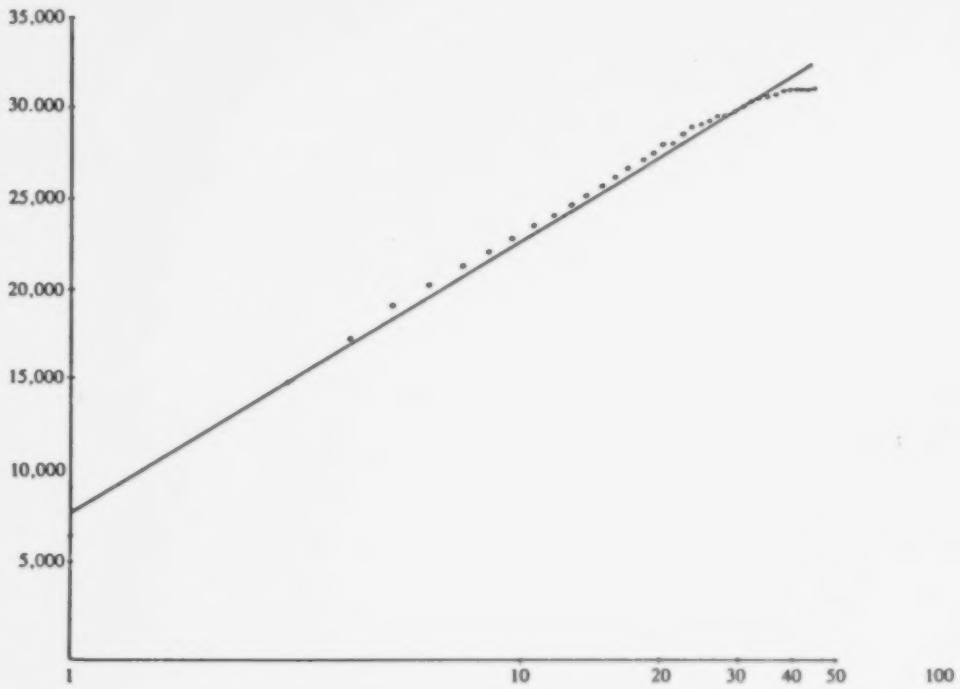



**Fig. 4.** *Semi-log plot of citations in databases*

The number of databases necessary to obtain a given percentage of the literature of emergency management approximates the $1 : a : a^2$ Bradford ratio. Two databases supply approximately one-third of the total relevant citations, 5 (rather than $2 \times 4$ or 8) additional databases supply the second one-third, but $2 \times 4^2$ or 32 databases supply the final one-third.

Fig. 5 shows a non-logarithmic plot of the data. It illustrates the phenomenon of diminishing returns with the total cumulation growing less and less rapidly with the addition of more databases. Because overlap was not taken into account, the total citation pool does not represent 100% unique citations. It is impossible to know exactly how many of the citations included in the databases with the fewest number of citations are new, unique citations.

Because the Bradford distribution's concentration of citations in the core does not apply to emergency management, no one database will yield a high percentage of the citations in the field. A cumulative frequency calculation (Fig. 6) allows the determination of the number of databases necessary to be searched to obtain a given percentage of the citations. No one database supplies over 19.3% of the total

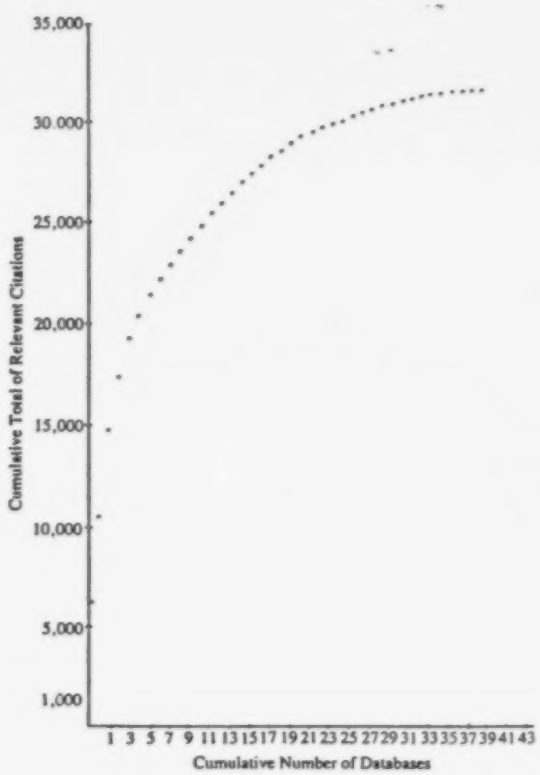



**Fig. 5.** *Number of databases searched for relevant citations.*

citations [23]. The cut-off in searching could be made at a point that would best satisfy an individual request. Some researchers may be satisfied with a 60.7% recall from a search of five databases, others might need a search of the 13–19 databases necessary for 80.6%–89.3% recall. The cost of attempting to achieve 100% recall goes up dramatically as compared to the recall benefits achieved. Clearly, Evans' blanket policy of limiting most searches to one or two databases would be disastrous in this field.

## 6. Conclusions and suggestions for further study

Database citations relevant to a multidisciplinary field have been shown to adhere to Bradford's law, or more specifically to follow a Zipf semi-logarithmic plot. Databases can be grouped into three zones, each yielding an equal number of citations, yet each successively containing dramatically more databases.

This phenomenon of diminishing returns might be expected intuitively, but the exact number of databases could not be guessed and has significant practical implications for online searching in multidisciplinary fields. Knowledge of the

Fig. 6. *Cumulative citations in databases*

| | *Database* | *Number of citations* | *Cumulative citations* | *Cumulative percent* |
|---|---|---|---|---|
| 1. | DOE Energy | 6089 | 6089 | 19.3% |
| 2. | NTIS | 4401 | 10490 | 33.3% |
| 3. | SSIE | 4317 | 14807 | 47.0% |
| 4. | GPO Monthly | 2460 | 17267 | 54.8% |
| 5. | Compendex | 1852 | 19119 | 60.7% |
| 6. | Enviroline | 1292 | 20411 | 64.8% |
| 7. | Health Planning | 922 | 21333 | 67.8% |
| 8. | Pollution | 818 | 22151 | 70.4% |
| 9. | NCJRS | 753 | 22904 | 72.7% |
| 10. | Safety Science | 746 | 23650 | 75.1% |
| 11. | ABI/Inform | 589 | 24239 | 77.0% |
| 12. | GeoRef | 581 | 24820 | 78.8% |
| 13. | Inspec | 568 | 25388 | 80.6% |
| 14. | Chemical Abstracts | 559 | 25947 | 82.4% |
| 15. | CAB Abstracts | 493 | 26440 | 84.0% |
| 16. | Medline | 485 | 26925 | 85.5% |
| 17. | Agricola | 425 | 27350 | 86.9% |
| 18. | Excerpta Medica | 391 | 27741 | 88.1% |
| 19. | Frost & Sullivan DM | 371 | 28112 | 89.3% |
| 20. | Energyline | 362 | 28474 | 90.4% |
| 21. | Eric | 345 | 28819 | 91.5% |
| 22. | Aptic | 302 | 29121 | 92.5% |
| 23. | Environmental Bib. | 221 | 29342 | 93.2% |
| 24. | GeoArchive | 220 | 29562 | 93.9% |
| 25. | Oceanic Abstracts | 219 | 29781 | 94.6% |
| 26. | NCMH | 207 | 29988 | 95.2% |
| 27. | Life Sciences | 191 | 30179 | 95.9% |
| 28. | Met/Geo | 184 | 30363 | 96.4% |
| 29. | Magazine Index | 154 | 30517 | 96.9% |
| 30. | PsycInfo | 145 | 30662 | 97.4% |
| 31. | SciSearch | 142 | 30804 | 97.8% |
| 32. | Conference Papers | 133 | 30937 | 98.3% |
| 33. | CRIS/USDA | 120 | 31057 | 98.6% |
| 34. | IH State Pubs. | 110 | 31167 | 99.0% |
| 35. | PAIS | 94 | 31261 | 99.3% |
| 36. | Sociological Abstracts | 92 | 31353 | 99.6% |
| 37. | Biosis | 68 | 31421 | 99.8% |
| 38. | Comprehensive Diss. | 55 | 31476 | 99.9% |
| 39. | Population Bib. | 8 | 31484 | 99.9% |
| 40. | EIS | 1 | 31485 | 100.0% |

number of databases necessary to be searched to yield a given percentage of the literature and the individual databases that contain the most citations relevant to emergency management will assist in the search process. It will allow searchers to choose the databases that will yield the most return.

The same methodology should be applied to other multidisciplinary fields to determine if general conclusions drawn from studying one are transferable to others. If it could be demonstrated that multidisciplinary fields have characteristics in common, assistance in choosing the optimum number of databases could be transferable.

Additionally, narrow subjects should be tested on databases to see if Bradford's law of scatter always applies to citations within databases. A comparison of the findings from these subject-specific tests with the tests from multidisciplinary fields could lead to useful conclusions about the nature of scatter of materials in databases.

Overlap of specific citations among databases was not considered in this study because correcting for overlap is more complicated and necessitates a larger sample size. It would be interesting to test if, when overlap is considered, the results would adhere even more closely to the linear plot.

These many aspects of the issues of choice and number of databases require further study. As the number of databases continues to increase, as subject fields become increasingly multidisciplinary, and with the continuing addition of database vendors, these issues will need to be addressed.

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# 4. Anwendung der Regel auf bestimmte Literaturgruppen

## 4.1 Medizinische Literatur

Vorbemerkung:

Eine übersichtliche Hinführung zu dieser Problematik wurde von Hoffmann und Klawitter-Pommer (1977) vorgelegt:

> Zur vollständigen Dokumentation der Literatur eines speziellen Fachgebietes ist es notwendig, den Umfang der im Fachgebiet erscheinenden wissenschaftlichen Zeitschriften festzustellen. Verschiedentlich wurden solche Aufstellungen über Zählungen von Zitaten in wissenschaftlichen Veröffentlichungen (1) und durch Ausleihfrequenz in den einschlägigen Fachbibliotheken (2, 3) durchgeführt. Für einige Disziplinen ist das auch bereits in Form von Zeitschriften- oder Periodika-Listen geschehen, z. B. von *Haendler* und *Neese* (4) für die Tierische Produktion und von *Schönherr* (5) für die Veterinärmedizin.
>
> Diese Zusammenstellungen sind meist sehr umfangreich und umfassen nicht nur das eigentlich angesprochene Fachgebiet, sondern vernünftigerweise auch die angrenzenden Disziplinen. *Schönherr* (5) erhielt durch Auswertung von Titelverzeichnissen und Bibliothekskatalogen eine Gesamtzahl von über 2 000 Periodika der gesamten veterinärmedizinischen Weltliteratur und ihrer Grenzgebiete. Eine Vorarbeit hierzu leistete *Blossfeldt* (6), der in seiner Dissertation eine Liste der englischsprachigen Publikationsorgane der Veterinärmedizin und ihrer Grenzgebiete vorlegte. Bei den genannten Arbeiten konnte jedoch nicht kontrolliert werden, ob die aufgeführten Zeitschriften bzw. Periodika von den Tierärzten auch tatsächlich benutzt oder benötigt wurden. In der vorliegenden Untersuchung wird mit einer anderen Methode dargestellt, welche Publikationsorgane von den Tierärzten tatsächlich gebraucht und verwendet werden.

Die oben gemachten allgemeinen Ausführungen werden in der Spezialuntersuchung der gleichen Autoren spezifiziert dargestellt. Die Veröffentlichung ist ein instruktives Beispiel aus der wenigen deutschen Literatur, die es zu dieser Problematik gibt.

28) Hoffmann, W. D.; Klawitter-Pommer, J. H. T.: Relevante Zeitschriften für die Veterinärmedizin
NfD 28(1977)2, S. 64-67

# Relevante Zeitschriften für die Veterinärmedizin — Versuch einer Analyse anhand von fünf Literatur-Datenbasen.

von Wolf D. *Hoffmann* und Jutta H. T. *Klawiter-Pommer*, Hannover

**Summary:**

*Die auf 90 veterinärmedizinische Fragen recherchierten relevanten Literaturzitate aus den Datenbasen Biosis, Cain, Index veterinarius, Medlars und Pascal werden auf ihre Herkunft untersucht. Die am häufigsten mit relevanten Publikationen genannten Zeitschriften werden zusammengestellt, nach Herkunftsländern aufgeschlüsselt und nach dem Vorkommen in den fünf Datenbasen eingeteilt. Die Zahl der relevanten Dokumente wird zu der Anzahl der Zeitschriften in Beziehung gesetzt (Bradford'sches Verteilungsgesetz).*

*Relevant publications which were found in the five data Bases Biosis, Cain, Index veterinarius, Medlars, and Pascal on 90 veterinary questions are analysed on their provenance. Journals with most relevant articles are compiled and arranged according to their countries of origin and the occurance within the five data Bases. The number of relevant documents is brought into relation to the number of journals (Bradford's law of distribution).*

Zeitschriften;
Vergleichende Untersuchungen;
Veterinärmedizin

## Einleitung:

Zur vollständigen Dokumentation der Literatur eines speziellen Fachgebietes ist es notwendig, den Umfang der im Fachgebiet erscheinenden wissenschaftlichen Zeitschriften festzustellen. Verschiedentlich wurden solche Aufstellungen über Zählungen von Zitaten in wissenschaftlichen Veröffentlichungen (1) und durch Ausleihfrequenz in den einschlägigen Fachbibliotheken (2, 3) durchgeführt. Für einige Disziplinen ist das auch bereits in Form von Zeitschriften- oder Periodika-Listen geschehen, z. B. von *Haendler* und *Neese* (4) für die Tierische Produktion und von *Schönherr* (5) für die Veterinärmedizin.

Diese Zusammenstellungen sind meist sehr umfangreich und umfassen nicht nur das eigentlich angesprochene Fachgebiet, sondern vernünftigerweise auch die angrenzenden Disziplinen. *Schönherr* (5) erhielt durch Auswertung von Titelverzeichnissen und Bibliothekskatalogen eine Gesamtzahl von über 2 000 Periodika der gesamten veterinärmedizinischen Weltliteratur und ihrer Grenzgebiete. Eine Vorarbeit hierzu leistete *Blossfeldt* (6), der in seiner Dissertation eine Liste der englischsprachigen Publikationsorgane der Veterinärmedizin und ihrer Grenzgebiete vorlegte. Bei den genannten Arbeiten konnte jedoch nicht kontrolliert werden, ob die aufgeführten Zeitschriften bzw. Periodika von den Tierärzten auch tatsächlich benutzt oder benötigt wurden. In der vorliegenden Untersuchung wird mit einer anderen Methode dargestellt, welche Publikationsorgane von den Tierärzten tatsächlich gebraucht und verwendet werden.

## Material und Methode

Im Zeitraum 1974 bis 1976 wurde in der Abteilung für Dokumentation des Instituts für Statistik und Biometrie der Tierärztlichen Hochschule Hannover eine Studie zum Informationsbedarf der Veterinärmediziner in den Europäischen Gemeinschaften durchgeführt, die von der EG-Kommission in Auftrag gegeben worden war (7). Auf 90 Fragen aus sämtlichen Sachgebieten der Tiermedizin, die von Wissenschaftlern aus den neun EG-Mitgliedsstaaten gestellt worden waren, erhielten wir insgesamt 73 954 Literaturhinweise von zehn Literatur-Datenbasen. Diese Referenzen verteilten sich auf ca. 5 000 Zeitschriften und 1 000 Monographien, die Zeitschriften der „Schönherr-Liste" (5) sind darin bereits enthalten.

Die Referenzen wurden den Fragestellern zur Relevanzbeurteilung vorgelegt. Es wurde überprüft, aus welchen Zeitschriften die als *relevant* beurteilten Zitate stammten, an Hand der ausgezählten Frequenzen wurden Ranglisten erstellt. Es kann allerdings kein Anspruch auf Vollständigkeit erhoben werden, da das ausgewertete Material den Zeitraum von 1972 bis 1974 umfaßt. Zeitschriften, die später herausgegeben wurden und schon eine weite Verbreitung haben, konnten nicht berücksichtigt werden. Des weiteren wurden lediglich die Zeitschriftenpublikationen der fünf Datenbasen Biosis (Biosciences Information Service of Biological Abstracts Previews), Cain (Cataloging and Indexing System, National Agricultural Library), Index veterinarius, Medlars (Medical Literature Analysis and Retrieval System) und Pascal (Programme Appliqué à la Sélection et la Compilation Automatique de la Litterature) genauer untersucht. Die Literaturstellen der anderen fünf Datenbasen wurden nicht berücksichtigt, da die 90 Testfragen komplett nur an die aufgeführten fünf Datenbasen geschickt worden waren. Die untersuchten Datenbasen dokumentieren Literatur aus der ganzen Welt mit biologischen, medizinischen, veterinärmedizinischen, landwirtschaftlichen und polywissenschaftlichen Sachgebieten. Weiterhin berücksichtigten wir nicht die relevanten Monographien.

Die Literaturhinweise aus den Datenbasen fielen in unterschiedlicher Gestalt an, so daß Vereinheitlichung und Kondensierung der gesammelten Daten notwendig waren. Um eine maschinelle Auswertung zu ermöglichen, übertrugen wir folgende Parameter einer Publikation auf Maschinenlochkarten: Systemcode, Fragenummer, Autorenname, Journalcode, Seitenzahl, Jahrgang und Relevanzurteil. Mit einer Rechenanlage (IBM 1130) wurden die als relevant beurteilten Publikationen extrahiert.

Für den nächsten Arbeitsgang waren lediglich die Zeitschriften- und Systemcodierungen erforderlich, so daß eine weitere Datenreduktion erfolgen konnte, durch Frequenzermittlung wurden Ranglisten nach verschiedenen Gesichtspunkten erstellt. Zunächst wurde festgehalten, welche Zeitschriften am meisten genannt worden waren, und zweitens, welche Staffelung innerhalb der Systeme

vorlag. Eine Einteilung nach den Herkunftsländern der Fachzeitschriften ermöglichte die Bestimmung der am häufigsten vertretenen Länder.

## Ergebnisse der Untersuchung

*Die am häufigsten genannten Journale*

Von den Datenbasen Biosis (B), Cain (C), Index veterinarius (I), Medlars (M) und Pascal (P) wurden insgesamt 1860 verschiedene Journale mit relevanten Publikationen recherchiert. Eine Auflistung der vorkommenden Journale nach der Häufigkeit ihrer Nennungen zeigt Tab. 1. In der Tabelle werden 43 Zeitschriften aufgeführt, die 50mal und öfter genannt wurden, während 1 817 Zeitschriften unter 50mal recherchiert wurden. Die 43 Zeitschriften mit den meisten Nennungen werden in absteigender Reihenfolge mit Angabe des Herkunftslandes (Abkürzung), der absoluten Häufigkeit der Nennungen und der Angabe der Datenbasen, die die Zeitschrift genannt haben, tabelliert. Diese 43 Zeitschriften, das sind 2,3% aller genannten relevanten Zeitschriften, enthalten nicht weniger als 69,5%

Tab. 1: Die am häufigsten (> 50 mal) von den Datenbasen Biosis, Cain, Index veterinarius, Medlars und Pascal genannten Zeitschriften mit relevanten Publikationen.

| Journal | Herkunftsland | absolute Häufigkeit | Datenbasen | | | | |
|---|---|---|---|---|---|---|---|
| | | | B | C | I | M | P |
| Journal of the Amer. Veterinary Medical Assoc. | USA | 491 | X | X | X | X | X |
| The Veterinary Record | UKD | 412 | X | X | X | X | |
| American Journal of Veterinary Research | USA | 348 | X | X | X | X | X |
| Journal of Animal Science | USA | 274 | X | X | X | X | X |
| Veterinarian | USS | 179 | X | X | X | X | |
| Journal of Dairy Science | USA | 168 | X | X | X | X | X |
| Cornell Veterinarian | USA | 143 | X | X | X | X | X |
| Research in Veterinary Medicine | UKD | 135 | X | X | X | X | X |
| Medycyna Weterynaryjna | POL | 134 | X | X | X | | X |
| Australian Veterinary Journal | AUS | 131 | X | X | X | X | X |
| Monatshefte für Veterinärmedizin | DDR | 129 | X | X | X | X | |
| Tijdschrift voor Diergeneeskunde | NET | 119 | X | X | X | X | |
| Deutsche Tierärztliche Wochenschrift | BRD | 118 | X | X | X | X | X |
| Journal of the Small Animal Practice | UKD | 111 | X | X | X | X | X |
| British Poultry Science | UKD | 102 | X | X | X | X | X |
| Wiener Tierärztliche Monatsschrift | AUT | 95 | X | X | X | X | X |
| Poultry Science | USA | 92 | X | X | X | X | X |
| Schweizer Archiv für Tierheilkunde | SWI | 88 | X | X | X | X | X |
| Veterinary Research and Small Animal Clinician | USA | 86 | | X | X | X | X |
| Nordisk Veterinärmedicin | DEN | 85 | X | X | X | X | |
| Infection and Immunity | USA | 84 | X | X | X | X | X |
| Gefluegel Welt | BRD | 82 | X | | | | |
| Experimental Parasitology | USA | 77 | X | X | X | X | X |
| Zentralblatt für Veterinärmedizin, Abt. A | BRD | 77 | X | X | X | X | X |
| Berliner und Münchener Tierärztliche Wochenschrift | BRD | 75 | X | X | X | X | |
| Journ. of the Association of Official Analyt. Chemists | USA | 73 | X | X | X | X | X |
| Avian Diseases | USA | 72 | X | X | X | X | |
| Journal of Food Science | USA | 69 | X | X | X | | X |
| Zentralblatt für Veterinärmedizin, Abt. B | BRD | 66 | X | X | X | X | X |
| Bulletin of Environmental Contamination and Toxicol. | USA | 66 | X | X | X | X | X |
| Acta Veterinaria Scandinavica | DEN | 63 | X | X | X | X | |
| Journal of Nutrition | USA | 60 | X | X | X | X | X |
| Journal of Economic Entomology | USA | 58 | X | X | X | X | X |
| Federation Proceedings | USA | 58 | X | | X | X | X |
| Veterinarnomedicinski Nauki | BUL | 57 | X | X | X | X | X |
| Atti della Societa Italiana delle Scienze Veterinar. | ITA | 56 | X | X | X | | X |
| Parasitology | UKD | 54 | X | X | X | X | X |
| Revue de Medecine Veterinaire | FRA | 54 | X | X | X | | X |
| Applied Microbiology | USA | 53 | X | X | X | X | X |
| Tierärztliche Umschau | BRD | 51 | | X | X | | X |
| Archiv für Lebensmittelhygiene | BRD | 51 | X | X | X | | X |
| Transactions of the Royal Soc. of Trop. Med. and Hyg. | UKD | 50 | X | | X | X | X |
| Journal of Hygiene | UKD | 50 | X | X | X | X | X |

der gesamten Nennungen. An erster Stelle liegt die amerikanische Zeitschrift „Journal of the American Veterinary Medical Association", aus der 491mal von den fünf Datenbasen recherchiert wurde.

Überraschenderweise befindet sich unter den 15 mehr als 100 mal genannten Zeitschriften jeweils eine Zeitschrift aus der UdSSR, Polen, Australien, Niederlande und der Bundesrepublik Deutschland. Die übrigen neun Zeitschriften stammen aus den USA oder dem Vereinigten Königreich.

*Herkunftsländer der Journale*

Teilt man die insgesamt 1 860 verschiedenen Zeitschriften nach ihren Herkunftsländern ein (Tab. 2), dann wird ersichtlich, daß fast 55% der Zeitschriften mit relevanten Artikeln, die von den Datenbasen Biosis, Cain, Index vete-

Tab. 2: Rangfolge der Herkunftsländer der von den Datenbasen Biosis, Cain, Index veterinarius, Medlars und Pascal genannten Zeitschriften mit relevanten Publikationen.

| Rang | Herkunftsland | Häufigkeiten absolut | relativ |
|---|---|---|---|
| 1 | USA | 463 | 24,89 |
| 2 | Großbritannien | 158 | 8,49 |
| 3 | B.R.Deutschland | 144 | 7,74 |
| 4 | Frankreich | 125 | 6,72 |
| 5 | UdSSR | 121 | 6,50 |
| 6 | Japan | 92 | 4,95 |
| 7 | Schweiz | 65 | 3,49 |
| 8 | Italien | 58 | 3,12 |
| 9 | Polen | 45 | 2,42 |
| 10 | Niederlande | 44 | 2,37 |
| 11 | DDR | 35 | 1,88 |
| 11 | Tschechoslowakei | 35 | 1,88 |
| 13 | Indien | 30 | 1,61 |
| 14 | Australien | 28 | 1,51 |
| 15 | Kanada | 25 | 1,34 |
| 16 | Dänemark | 23 | 1,24 |
| 16 | Schweden | 23 | 1,24 |
| 16 | Belgien | 23 | 1,24 |
| 19 | Rumänien | 21 | 1,13 |
| 19 | Jugoslawien | 21 | 1,13 |
| 21 | Brasilien | 20 | 1,08 |
| 22 | Ungarn | 16 | 0,86 |
| 22 | Süd-Afrika | 16 | 0,86 |
| 24 | Spanien | 15 | 0,81 |
| 25 | Bulgarien | 12 | 0,65 |
| 25 | Neuseeland | 12 | 0,65 |
| 27 | Österreich | 11 | 0,59 |

rinarius, Medlars und Pascal ausgewertet wurden, aus den USA, Großbritannien, Bundesrepublik Deutschland, Frankreich und der UdSSR stammen. Zusammen sind es 48 Länder, von denen 27 in Tab. 2 aufgeführt sind. Weitere 21 Länder weisen jeweils weniger als 10mal genannte Zeitschriften auf (unter 0,5% der Nennungen). Die USA liegen mit nahezu 25% der Zeitschriften auf Platz 1, gefolgt von Großbritannien (8,5%) und der Bundesrepublik Deutschland (7,7%). Addiert man die Zeitschriftenanzahlen der DDR und BRD (insgesamt 179), so erreichen die Bundesrepublik Deutschland und die Deutsche Demokratische Republik zusammen Platz 2.

*Verteilung der Zeitschriften auf die Systeme:*

Werden die Journale gemäß ihrer Nennung nach den Datenbasen Biosis, Cain, Index veterinarius, Medlars und Pascal aufgeschlüsselt, ergeben sich die Tab. 3 bis 7. Wir

Tab. 3: Die zehn am häufigsten genannten Zeitschriften der Datenbasis Biosis.

| Rang | Journal | Herkunftsland | absolute Häufigkeit |
|---|---|---|---|
| 1 | Journal of the American Veterinary Medical Association | USA | 222 |
| 2 | American Journal of Veterinary Research | USA | 108 |
| 3 | The Veterinary Record | UKD | 96 |
| 4 | Gefiederte Welt | BRD | 82 |
| 5 | Journal of Small Animal Practice | USA | 77 |
| 6 | Journal of Animal Science | USA | 61 |
| 7 | Journal of Dairy Science | USA | 53 |
| 8 | Cornell Veterinarian | USA | 43 |
| 8 | Agricultural Magazine | UKD | 43 |
| 10 | Medycyna Weterinaryjs | POL | 39 |
| 10 | Federation Proceedings | USA | 39 |

Tab. 4: Die zehn am häufigsten genannten Zeitschriften der Datenbasis Cain.

| Rang | Journal | Herkunftsland | absolute Häufigkeit |
|---|---|---|---|
| 1 | The Veterinary Record | UKD | 58 |
| 2 | American Journal of Veterinary Research | USA | 48 |
| 3 | Monatshefte für Veterinärmedizin | DDR | 40 |
| 4 | Tijdschrift voor Diergeneskunde | NET | 38 |
| 4 | Veterinariya | USS | 38 |
| 6 | Journal of the American Veterinary Medical Association | USA | 37 |
| 7 | Medycyna Weterinaryjs | POL | 25 |
| 8 | Australian Veterinary Journal | AUS | 24 |
| 8 | Die Fleischwirtschaft | BRD | 24 |
| 10 | Deutsche Tierärztliche Wochenschrift | BRD | 23 |

Tab. 5: Die zehn am häufigsten genannten Zeitschriften der Datenbasis Index veterinarius.

| Rang | Journal | Herkunftsland | absolute Häufigkeit |
|---|---|---|---|
| 1 | The Veterinary Record | UKD | 96 |
| 2 | Journal of the American Veterinary Medical Association | USA | 45 |
| 3 | American Journal of Veterinary Research | USA | 44 |
| 4 | Tijdschrift voor Diergeneskunde | NET | 40 |
| 5 | Monatshefte für Veterinärmedizin | DDR | 37 |
| 5 | Veterinariya | USS | 37 |
| 7 | Medycyna Veterinaryjs | POL | 36 |
| 8 | Deutsche Tierärztliche Wochenschrift | BRD | 35 |
| 9 | Australian Veterinary Journal | AUS | 26 |
| 10 | Zentralblatt für Veterinärmedizin Abt. A | BRD | 25 |

Tab. 6: Die zehn am häufigsten genannten Zeitschriften der Datenbasis Medlars.

| Rang | Journal | Herkunftsland | absolute Häufigkeit |
|---|---|---|---|
| 1 | The Veterinary Record | UKD | 162 |
| 2 | Journal of the American Veterinary Medital Association | USA | 149 |
| 3 | Veterinariya | USS | 100 |
| 4 | Journal of Animal Science | USA | 87 |
| 5 | American Journal of Veterinary Research | USA | 84 |
| 6 | Deutsche Tierärztliche Wochenschrift | BRD | 56 |
| 7 | Australian Veterinary Journal | AUS | 54 |
| 8 | Journal of Dairy Science | USA | 50 |
| 9 | Cornell Veterinarian | USA | 49 |
| 10 | Veterinary Medicine and Small Animal Clinician | USA | 44 |

Tab. 7: Die zehn am häufigsten genannten Zeitschriften der Datenbasis Pascal.

| Rang | Journal | Herkunftsland | absolute Häufigkeit |
|---|---|---|---|
| 1 | American Journal of Veterinary Research | USA | 55 |
| 2 | Journal of the American Veterinary Medical Association | USA | 38 |
| 3 | Journal of Animal Science | USA | 35 |
| 4 | Medycyna Veterinaryjs | POL | 34 |
| 5 | Research in Veterinary Science | UKD | 32 |
| 6 | Journal of Food Science | USA | 27 |
| 7 | Journal of Dairy Science | USA | 25 |
| 8 | Wiener Tierärztliche Monatsschrift | AUT | 23 |
| 8 | Archiv für Lebensmittelhygiene | BRD | 23 |
| 10 | Bulletin of Environmental Contamination and Toxicology | USA | 22 |

haben, um die Tabellen nicht zu umfangreich werden zu lassen, jeweils nur die ersten zehn am häufigsten genannten Journale aufgeführt. Biosis nannte relevante Publikationen aus 779 Zeitschriften, Cain aus 575, Index veterinarius aus 531, Medlars aus 769 und Pascal aus 527.

Die ersten zwei Plätze werden bei allen Systemen von den Zeitschriften „Journal of the American Veterinary Medical Association", „American Journal of Veterinary Research" und „The Veterinary Record" wechselweise bestritten. Letztere wird von Pascal allerdings nicht ausgewertet.

Bestimmte Journale werden nur von einem System unter den ersten zehn häufigsten genannt. Bei Biosis sind es die Zeitschriften „Gefiederte Welt", „Journal of Small Animal Practice", „Agricultural Magazine" und „Federation Proceedings".

Bei Cain ist es „Die Fleischwirtschaft", bei Index veterinarius „Zentralblatt für Veterinärmedizin, Abt. A"; bei Medlars „Veterinary Medicine and Small Animal Clinician" und bei Pascal „Research in Veterinary Science", „Journal of Food Science", „Wiener Tierärztliche Monatsschrift", „Archiv für Lebensmittelhygiene" und „Bulletin of Environmental Contamination and Toxicology". Alle Journale betreffen rein veterinärmedizinische Sachgebiete und ihre Grenzbereiche. Auf Grund der Zeitschriftentitel läßt sich daher nicht einwandfrei feststellen, ob ein System die Veterinärmedizin vernachlässigt.

*Relation zwischen relevanten Dokumenten und Zeitschriften*

Nach dem sog. Bradford'schen Verteilungsgesetz (8) lassen sich die Zeitschriften eines Fachgebietes in einen Kern (Nucleus) und darumliegende Zonen einteilen, wobei die Zahl der in diesen Zonen enthaltenen relevanten Dokumente annähernd gleich bleiben soll, während sich die Anzahl der Journale ständig erhöht. Wir haben in Tab. 8

Tab. 8: Einteilung der Zeitschriften mit relevanten Publikationen nach dem „Bradford'schen Verteilungsgesetz" nach Zonen.

| | Anzahl der Journale | | | | Anzahl der relevanten Dokumente | | | |
|---|---|---|---|---|---|---|---|---|
| | in der Zone | | Kumuliert | | in der Zone | | Kumuliert | |
| Zone | absolut | relativ | absolut | relativ | absolut | relativ | absolut | relativ |
| Kern | 3 | 0,16 | 3 | 0,16 | 1 242 | 9,77 | 1 242 | 9,77 |
| 1 | 8 | 0,43 | 11 | 0,59 | 1 242 | 9,77 | 2 484 | 19,53 |
| 2 | 13 | 0,69 | 24 | 1,29 | 1 211 | 9,52 | 3 695 | 29,06 |
| 3 | 21 | 1,13 | 45 | 2,42 | 1 233 | 9,70 | 4 928 | 38,75 |
| 4 | 31 | 1,67 | 76 | 4,09 | 1 242 | 9,77 | 6 170 | 48,52 |
| 5 | 48 | 2,58 | 124 | 6,67 | 1 234 | 9,70 | 7 404 | 58,22 |
| 6 | 86 | 4,62 | 210 | 11,29 | 1 238 | 9,74 | 8 642 | 67,96 |
| 7 | 161 | 8,66 | 371 | 19,95 | 1 238 | 9,74 | 9 880 | 77,69 |
| 8 | 311 | 16,72 | 682 | 36,67 | 1 239 | 9,74 | 11 119 | 87,43 |
| 9 | 820 | 44,09 | 1 502 | 80,75 | 1 240 | 9,75 | 12 359 | 97,18 |
| 10 | 358 | 19,25 | 1 860 | 100 | 358 | 2,82 | 12 717 | 100 |

die Zahl der relevanten Dokumente bei annähernd 1240 gehalten (6. Spalte der Tabelle), um zehn Zonen zu erhalten. Die Anzahl von 1242 relevanten Dokumenten im Kern wurde bereits von drei Journalen erreicht (Spalte 2 der Tabelle), in der 1. Zone durch acht, in der 2. Zone durch 13 und in den weiteren Zonen durch eine immer größer werdende Anzahl von Journalen. In der 9. Zone sind für die Nennung von 1 240 relevanten Dokumenten 820 Journale notwendig. Knapp 50% der relevanten Dokumente (Spalte 9 der Tabelle) werden bereits in der 4. Zone durch 76 Jour-

nale (Spalte 4 der Tabelle) erreicht, d. h. 4,09% der Journale (Spalte 5 der Tabelle) liefern bereits 48,52% der relevanten Dokumente.

Die in Tab. 8 aufgeführten Werte sind in Abbildung 1 graphisch dargestellt. Die Kurve verdeutlicht, daß man mit erstaunlich wenig Primärzeitschriften hohe Anteile relevanter Literatur eines Fachgebietes erfassen kann. 50% der Journale liefern 92% der relevanten Dokumente, 10% der Journale enthalten 65% der relevanten Dokumente. Diese Aufstellung und die Methode nach Bradford müssen aber auch kritisch betrachtet werden. Unter den Zeitschriften, die nur wenig relevante Dokumente geliefert haben, befinden sich auch ganz spezifische Fachzeitschriften aus dem untersuchten Fachgebiet. Haendler und

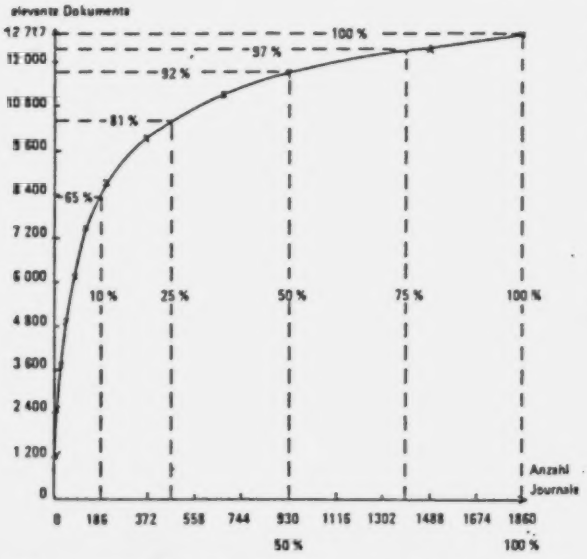


Abb. 1: Darstellung der Ergebnisse aus Tab. 8 in graphischer Form. Relation der ausgewerteten Zeitschriften (Abszisse) zu den in ihnen enthaltenen relevanten Publikationen (Ordinate).

Neese (4) stellten deshalb das Bradford'sche Gesetz in Frage, indem sie formulierten: „Die absolute Anzahl relevanter Dokumente pro Periodikum stellt kein brauchbares Kriterium für deren Berücksichtigung dar ... sondern in erster Linie der relative Anteil am gesamten Inhalt (eines Periodikums), eine Tatsache, die von Bradford wie anderen Autoren bisher völlig übersehen wurde."

*Zusammenfassung und Diskussion*

Aus der Untersuchung geht hervor, daß nur sehr wenige Zeitschriften eine überragende Bedeutung für die Veterinärmedizin haben. Bemerkenswert ist, daß fast dieselben Zeitschriften von fünf verschiedenen Datenbasen genannt wurden, die Literatur verschiedener Wissensbereiche wie Medizin, Biologie, Landwirtschaft etc. speichern. Die am häufigsten genannten Zeitschriften kommen aus den Ländern USA, Vereinigtes Königreich und Bundesrepublik Deutschland. Auch in dieser Untersuchung bestätigt sich wieder das Bradford'sche Gesetz, daß nur ein geringer Prozentsatz an Zeitschriften einen hohen Prozentsatz an relevanten Dokumenten liefert.

Man muß bei dieser Untersuchung aber auch sämtliche negativen Einflüsse aufführen, die den Wert der Aussagen in Frage stellen. Auf die Unvollständigkeit wurde oben schon hingewiesen. Die Journale der Veterinärmedizin basieren in dieser Untersuchung auf den Recherchen nach 90 Fragen aus allen Bereichen der Veterinärmedizin. Die Fragen ließen sich in recht oberflächliche, umfassende und in sehr konkrete unterscheiden. Je konkreter natürlich eine Frage ist, desto eher besteht für eine Publikation aus einer Zeitschrift ein negatives Relevanzurteil, falls es auch nur geringfügig von der Fragestellung abweicht. Zudem ist eine Relevanzentscheidung durch 90 verschiedene Fragesteller nie objektiv. Trotz dieser Einwände sollte gezeigt werden, welche veterinärmedizinischen Zeitschriften für den Tierarzt interessant sind. Von ca. 4000 Zeitschriften (der fünf Datenbasen) wurden nur 43 Zeitschriften (mit *relevanten* Dokumenten) mehr als 50 mal genannt. Dennoch sollte man berücksichtigen, daß eine einmal genannte Zeitschrift, die eine für einen Wissenschaftler bedeutende Publikation enthält, nicht vernachlässigt werden darf. Die nächste Konsequenz dieser Untersuchung wäre, eine Zeitschriftenliste aufzustellen, die die Journale enthält, deren Publikationen mindestens einmal als relevant bezeichnet worden sind.

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(8) *Bradford*, S. C.: Complete Documentation. Report of the Royal Society Empire Scientific Conference, London (1946)

An der School of Medicine, University of South Dakota, wurden die Zitate, welche in der 48-monatigen Periode von 1972 - 1975 im Tropical Diseases Bulletin erschienen, untersucht. Es sollte festgestellt werden, in welchen Zeitschriften und in welcher Sprache die Zitate erscheinen.[29)]

Die Autoren betonen die praxisnahen Anwendungmöglichkeiten der Bradford'schen Methode im Bibliotheksbereich und empfehlen weitere empirische Untersuchungen.[30)]

29) Brennen, P.; Davey, W. P.: Citation analysis in the literature of tropical medicine
Bull. of the Med. Libr. Assoc. 66(1978)1, pp. 24-29

30) Drott, M. C.; Mancall, J. C.; Griffith, B. C.: Bradford's law and libraries
ASLIB proc. 31(1979)6, pp. 296-304

# Bradford's law and libraries: present applications—potential promise

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*Bradford's Law is presented as an observation made from the outcome of searching, rather than a mathematical development. The organization and presentation of search data is explained. Potential applications of Bradford's Law are discussed. New findings are presented which show the relationship described by Bradford's Law to be fundamentally important but in a more subtle way than previously supposed. Future developments are suggested in terms of their impact on librarianship.*

BRADFORD'S LAW IS based upon an observation which anyone who does literature searches can make. Namely, if one searches the journal literature for articles on any specific topic, a particular pattern will emerge. The pattern is that a fairly large number of the articles will be concentrated in a few journal titles while there will be a large number of journals which contribute only one or two articles each. This can be visualized more clearly by considering some data.

## Organizing data

As part of another research project we performed a search on a specialized topic in medicine. Or more properly, the search was performed for us on the Medline computer system. Upon sorting out the results of the search we found that 277 articles had been retrieved and that these represented ninety-seven journal titles. Looking more closely, we found that the largest number of articles contributed by a single title was thirty-seven. On the other hand there were fifty-six journals contributing only one article each. In order to portray this more clearly we created Table 1. Ranks were assigned to the journals so that the journal contributing the most articles was ranked number one; the journal with the next greatest number of articles was ranked number two; and so on. We have recorded this in Table 1 where each line represents a specific journal. In the first column we enter the rank, and in the second we record the number of articles contributed. Thus, looking at only the first two columns, we see that the first journal contributed thirty-seven articles while the next journal (rank two) contributed twenty-five. Scanning down the table, one can see that the number of articles contributed by each successive journal drops very quickly. On reaching the bottom of the table you will see that we have abbreviated the table to save printing space. The fifteen journals which were ranked twenty-seventh through forty-first contributed two articles each. These are reported in

condensed form in the table, as are the journals ranked forty-second through ninety-seventh which contributed only one article each.

In order to see what is happening more clearly, we add a third column headed 'cumulative articles' which reports a running total for the articles retrieved. On the first line are the thirty-seven articles retrieved by the first ranked journal. The sixty-two on the second line is the total number of articles from the first

| JOURNAL RANK | ARTICLES FROM JOURNAL | CUMULATIVE ARTICLES | CUMULATIVE PERCENTAGE OF ARTICLES |
|---|---|---|---|
| 1 | 37 | 37 | 13% |
| 2 | 25 | 62 | 22 |
| 3 | 14 | 76 | 27 |
| 4 | 12 | 89 | 32 |
| 5 | 12 | 101 | 36 |
| 6 | 8 | 109 | 39 |
| 7 | 7 | 116 | 41 |
| 8 | 6 | 122 | 44 |
| 9 | 6 | 128 | 46 |
| 10 | 5 | 133 | 48 |
| 11 | 5 | 138 | 50 |
| 12 | 5 | 143 | 52 |
| 13 | 5 | 148 | 53 |
| 14 | 4 | 152 | 55 |
| 15 | 4 | 156 | 56 |
| 16 | 4 | 160 | 58 |
| 17 | 4 | 164 | 59 |
| 18 | 3 | 167 | 60 |
| 19 | 3 | 170 | 61 |
| 20 | 3 | 173 | 62 |
| 21 | 3 | 176 | 63 |
| 22 | 3 | 179 | 64 |
| 23 | 3 | 182 | 65 |
| 24 | 3 | 185 | 66 |
| 25 | 3 | 188 | 67 |
| 26 | 3 | 191 | 68 |
| 27 thru 41 | 2 (15 × 2) | 221 | 80 |
| 42 thru 97 | 1 (56 × 1) | 277 | 100 |

TABLE 1: *The results of a search in terms of articles per journal*

two journals (thirty-seven from the first plus twenty-five from the second). Similarly the first three journals contributed a total of seventy-six articles. This continues on down the table. When we get to our fifteen journals tied at two articles each, we must remember to add thirty (that is fifteen times two) to the total.

The first three columns contain all of the information which we need to

describe the distribution of articles over journals. However, to make the discussion of the data easier we add a fourth column. The fourth column presents the cumulative percentage of articles retrieved. It is created by dividing each number in the third column by the total number of articles (in this case 277) and multiplying by 100 to give a percentage. We have rounded off these percentages since the extra precision would not give us any additional information.

Scanning down the fourth column we can now observe that with only the first three journal titles we could supply over one quarter (27 per cent) of all of the retrieved articles. Similarly twelve journals would suffice to supply over half (fifty-two per cent) of our articles. This approach can be used by a library to identify important journal titles or to select items for weeding.

## A statement of Bradford's Law

The pattern of the dispersion of articles over journals which we have just discussed is interesting but hardly up to the status of a law. The discovery which gave us a law was first published by S. C. Bradford[1] and it is this:

> It is possible to take all of the numbers representing cumulative number of articles retrieved (column three of the table) and to express them in a single mathematical formula.

This is a rather strong claim.

Consider all of the events represented by our search. An author decided to write an article; he selected a journal; the journal published it; the National Library of Medicine chose to index the journal; an indexer assigned terms; the same terms were selected for our search; and, finally, the document was retrieved. Yet the claim is made that, as far as the distribution of articles over journal titles is concerned, the outcome of this process is predictable.

This is the formula:

$R(n) = h \cdot \log n/s$ (B. C. Brookes[2])

This formula is for predicting the cumulative number of articles retrieved (column three of the table). In the formula, $n$ is the rank for which we wish to predict, and $R(n)$ is the corresponding cumulative number of articles.

That is to say $n$ and $R(n)$ correspond to the first and third columns of the table. By selecting any rank, one can use the formula to calculate an estimate for the corresponding cumulative frequency. For example, given a rank of five we would hope to calculate a value of cumulative frequency close to the actual number of articles, 101, which appears in the table. In the formula the variables $h$ and $s$ are constants—different for each search. In this case we have calculated the value of $h$ to be 140 and $s$ to be one.

Suppose we want to predict the cumulative number of articles contained in the first five journals. Using tables, we look up the log of five (the rank) and find .70. (Note that since $s$ is equal to one it has no effect on this calculation.) Multiplying by our constant of 140 gives ninety-eight as our prediction. The table gives us the actual number, 101. The formula was a bit low, but very close by the standards applied to laws in the social and behavioural sciences.

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## Comparison of observation and prediction

In order to see how well Bradford's Law predicts the outcome of our search

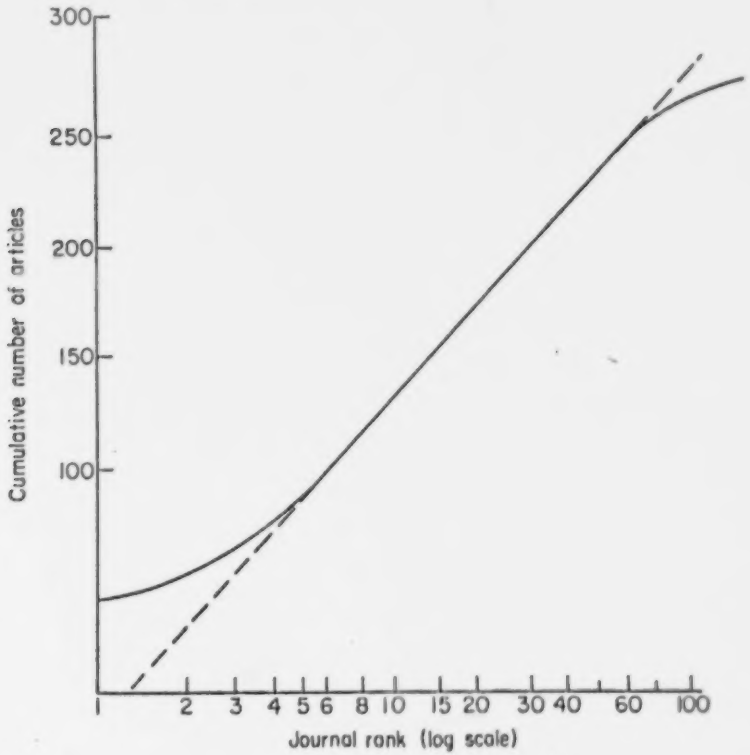



FIG. 1. *Predicted and observed values of a search*

we need to compare the predicted cumulative number of articles with the actual results of our search. One way of doing this is to draw a graph which shows both the predicted and observed values. Figure 1 is such a graph for the data which was presented earlier. The solid curve shows this data. Every row of the table becomes a point on the graph. On the horizontal axis we have log rank and on the vertical axis the cumulative number of articles. To plot an observed point we first look up the log of the rank, find this on the horizontal axis, and go straight up from this point until we are opposite the appropriate value of cumulative articles on the vertical axis. Doing this for every journal gives us the solid curve shown in the graph. (Note that because of the small size of the graph we have not tried to show each of the points.)

On the same graph we can plot a line (the dashed line in Figure 1) representing the values of cumulative number of articles predicted by Bradford's Law. Because of the nature of the formula the predicted values will always form a straight line. In many of the studies reported in the literature this line is not [redacted]

Bradford's Law would give can be shown by the straight line that most closely fits the curve. This can be done because the two constants in the Bradford's Law equation correspond to two properties of a straight line. The constant *b* reflects the slope of the line. A high value of *b* would result in a line which is closer to vertical, while a lower value would be more nearly horizontal. The constant *s* is a measure of where the line hits the horizontal axis. Low values of *s* mean that the line comes close to the point at which the axes meet.

An alternative way of drawing the line representing Bradford's Law is to determine the values of *b* and *s*. These can be calculated using the observed results of the search. The technique is called linear regression and formulas for it appear in many textbooks on statistics. (In the vocabulary of statistics cumulative number of articles would be called the independent variable while the log of the rank would be the dependent variable.) The calculations involved can be made with a pocket calculator. Many computer installations have pre-written programs which will do these calculations. For example, we used a package of programs called Statistical Package for the Social Sciences (SPSS). Given values for *b* and *s*, Bradford's Law can be used to calculate a predicted number of cumulative articles for each rank. These can then be plotted on the graph. Again, the points would all fall on the (dashed) straight line—the line of predicted values.

We can now look at the line and the curve on the graph and see how they compare with each other. If our predictions were perfect the two would be one on top of the other. The pattern which we see in this graph is very typical. In the first place the prediction is quite good, particularly in the middle part of the graph. At the lower part of the graph (the part that was drawn using the journals ranked one, two, three, *etc.*) we see that the prediction and the observation do not agree. The law is predicting that the first ranked journals should have more articles than they actually do. (The fact that the graph presents cumulative number of articles makes this finding hard to see. To be completely accurate one should say that the first journal contributes many more articles than estimated while the remaining top ranked journals each contribute fewer than the formula would call for.) Investigators have explained this as a 'saturation' of the journals. That is, for any particular topic the most important journals tend to limit the number of articles they will accept (or in the case of a journal devoted solely to a particular topic the limit is the number of pages in the journal). It is generally accepted that the equation representing Bradford's Law does not hold for the most important journals. This exception is minor in overall terms and tends to apply only to the first four or five journal titles.

We see from the graph that there is also a failure of Bradford's Law to predict the upper end of the observed data. The law predicts that more articles will be found than are actually located. (This has been called the 'Groos Droop' after the person who first reported it.[3]) The exact cause of this inconsistency is not completely understood. Some authors have suggested that it could be an indication of an incomplete search—that is the law is right but the searcher has not been sufficiently diligent. Another point of view is that the search is incomplete but that all actual searches must be incomplete. A third point of view holds that the present formulation of the law is wrong because it includes the

physical impossibility of a journal which contains a fraction of an article. In any case, the effect of this error on the accuracy of the prediction is minor.

### Potential application

The question to which we now turn is how Bradford's Law can have an impact on librarianship. There are two immediate applications of Bradford's Law which have been suggested. The first is to check on how well a search was done by comparing actual with predicted retrieval. The second application is the prediction of the outcome of a search before the search is done. The ability to do either or both of these things would be very significant and there have been reports in the literature suggesting that both might be possible. The necessary feature for such a suggestion to be valid is that the two constants in our equation ($b$ and $s$) are reflections of the nature of the search topic and of how well the search was done. If this is true, then by observing the value of the constants, we can rate the quality of the search, or by estimating the constants, we can predict the outcome of a search.

Here is how one could use the value of $b$ to evaluate a search. First the search is performed and the value of $b$ is calculated. This could then be used to predict the cumulative number of articles which would have been found in a complete search. Hence, we would have a theoretical standard against which we could compare an actual search.

In a similar manner if we could use our knowledge of the breadth of a particular subject and the thoroughness with which we intended to conduct a search we might predict $b$ and $s$ in advance. Thus we could predict the outcome of a search before the search was done. Such an ability would have great potential for acquisition planning and collection evaluation.

### Some recent findings

In order to find out more about how to predict the parameters of Bradford's Law we examined the outcomes of twenty-three different searches. Some of these were searches presented in the literature while others were done specifically for our study. The full results of this research are reported elsewhere.[4,5] However, because those reports are heavily based on mathematical analysis and statistical argument, we will reiterate the major points here.

Our sample collection of twenty-three searches represented a wide diversity of subject matter and search technique. Topics included several areas of medicine, two specialities in physics, social science topics, tropical agriculture, and marine biology. Some of our searches were compiled from a single abstracting and indexing service while others involved complete bibliographic searches. A variety of time spans were represented including the same topic searched over several years. The size of the retrieved sets varied from about three hundred articles in one hundred journals to more than eight thousand articles in seven hundred journals. This set of searches provided a rich environment in which to examine Bradford's Law with respect to different subject matters and search techniques.

Our first step was to use a computer to calculate $s$ and $b$ for each search and to test how well the predictions of Bradford's Law matched the actual search

results. All of the searches showed a very good agreement with Bradford's Law. In fact, in every case Bradford's Law explained better than ninety-two per cent of the variation in the cumulative number of articles. (In statistical terms, the correlations exceeded .96.) We take this to be a strong confirmation that the outcome of searches does follow Bradford's Law.

The next step was to look for patterns of topic and search techniques that would let us predict the values of $b$ and $s$ rather than calculate them from the completed search. We also tried to explain how closely the data fit the theoretical law in terms of the quality of the search. In both of these attempts we were unable to find any relationships which would help us to predict the values of $b$ and $s$.

The failure to find a method of predicting $b$ and $s$ does not mean that none exists. A more detailed study of the data might reveal subtle patterns or regularities. However, we believe there is a more straightforward explanation of the situation revealed by our data.

In the course of our analysis we found that there was a strong relationship between the value of $s$ and the *total number of journal titles retrieved*. There was a very strong relationship between $b$ and the *total number of articles retrieved*. (The correlations were .82 and .99 respectively.) Both of these relationships are much stronger than one would expect from the obvious fact that the number of journals and the number of articles are related to each other. (The correlation of total journals to total articles is .59.) If fact, these relationships are so strong that there is in a sense 'no room' left for search technique or topic to have an effect.

Our findings argue that all searches which produce the same total number of articles will have about the same value of $b$. All searches which produce the same number of journal titles will have similar values of $s$. This relationship will hold regardless of the breadth or narrowness of the topic, the subject matter, the time period covered or the manner in which the search is done. The only possible restriction may be that the search be of some reasonable level of quality or extent.

Perhaps our argument can best be illustrated with a parable. Suppose that two information scientists were to stage a contest the point of which was to predict the shape of the Bradford curve to be formed by the outcome of some particular search. A searcher performs the search and calculates the curve. The two researchers are allowed to ask questions in order to gather data on which to make their predictions. Let us suppose that the first researcher is allowed to ask only two questions: How many journal titles did you find? How many articles did you find? The second researcher may ask as many questions as he wishes about the nature of the subject matter being searched, the breadth of the questions, or the manner in which the search was conducted. The results of our study lead us to believe that the first information scientist, the one who knows nothing of the subject matter and has only two figures describing the output, will win. He will succeed in more accurately predicting the shape of the curve. This victory is a necessary consequence of the high correlations found in our results.

These findings cast doubt on the hypothesized applications of Bradford's

Law which were discussed above. The librarian who wishes to apply quantitative management techniques to the problems of the dispersion of articles over journals is left with a little insight and a great deal of reliance on judgment. The most useful tool in such a situation is a table such as our Table 1. From this, one can guess in a rather exact way the likely effect of limiting a search to only a small group of the most likely journals. One can see how changing the number of journals examined would change the overall potential of the search. Similarly the table can be used to help estimate the impact of dropping (or adding) subscriptions to relatively obscure journals. In both cases the selection of appropriate journal titles must depend heavily on professional judgment.

If Bradford's Law does not reflect the nature of specific searches we must consider what its potential value may be. First of all we should reiterate that Bradford's Law, in so far as it is a mathematical formula which describes, in general, the outcome of searches, is enormously accurate. The same pattern occurs again and again. Clearly, there must be some very basic reasons for this. Not only do we have Bradford's Law, we have similar observations from related fields. Zipf's Law describes the occurrence of words. Words (in any particular language) can be ranked in order of their frequency of occurrence. When rank is plotted against frequency of occurrence the pattern is mathematically identical to Bradford's Law. Similarly, if authors are ranked by the number of papers each of them has written, the pattern (called Lotka's Law) is of the same type. Other aspects of human behaviour also give rise to this kind of pattern.

Recent papers by B. C. Brookes[6] and Derek de Solla Price[7] have attempted to cast further light on Bradford's Law viewed as the manifestation of a fundamental underlying mathematical regularity. The discovery of regular mathematical patterns has been of great importance in both the physical and social sciences. For example, events as disparate as the outcomes of games of chance and the distribution of educational test scores give rise to a particular pattern. When graphed, this pattern forms a bell-shaped curve. (Today this bell-shaped curve is familiar in its widespread use by teachers in determining grades from test scores.) This curve is called the Normal Distribution.

The Normal Distribution forms the basis for a large part of modern statistics. If one is measuring some activity or phenomenon which follows a Normal Distribution, then one can make very precise statements about the accuracy of the observation or about the similarity (or dissimilarity) of different sets of data. This is done through the use of a set of mathematical tables which are calculated from the equations describing the Normal Distribution. A researcher simply looks in the appropriate table, applies a correction based on his particular situation, and is at once able to make some very definite statements about the results of his experiment.

We are, of course, not yet to this point with respect to the Bradford Distribution. Much theoretical work remains to be done. While we cannot see all possible impacts, we can suggest a simple situation in which such developments can be of use. Suppose that a librarian wishes to sample a collection in order to find out how much use is made of various materials. An important question is how accurately such a sample would portray actual use. Put another way, one might ask what sample size is needed to obtain some desired accuracy. Prelimin-

ary work shows that in such a case the required sample size (for a given degree of accuracy) is much larger than the sample size that would be required if the Normal Distribution was applicable.[8] This means that researchers using current statistical practices would drastically over-estimate the accuracy of their results.

## Conclusions

Bradford's Law is at once both a pervasive and an elusive phenomenon. At one time the ease with which the use pattern which Bradford's Law describes was detected, and the discovery of its mathematical regularity led investigators to hope that it could be easily applied to the quantitative solution of library problems. The discovery that this law describes an underlying probabilistic phenomenon rather than more superficial characteristics of the data casts doubt upon proposed applications. The exact importance of Bradford's Law remains to be determined. It does, however, seem that there is great potential for future impact on a wide variety of information related situations.

## REFERENCES


1 BRADFORD, S. C. *Documentation*. Washington, D.C.: Public Affairs, 1950.

2 BROOKES, B. C. The derivation and application of the Bradford–Zipf Distribution. *Journal of Documentation*, 24, December 1968, p. 247–65.

3 GROOS, O. V. Bradford's Law and the Keenan–Atherton data. *American Documentation*, 19, January 1967, p. 46.

4 DROTT, M. C. *and* GRIFFITH, B. C. An empirical examination of Bradford's Law and the scattering of scientific literature. *Journal of the American Society for Information Science*, 27, September 1978.

5 DROTT, M. C. The dispersion of scientific literature: some implications for management. *Management of Information Systems; Papers Presented at the Seventh Mid-Year Meeting of the American Society for Information Science*. Houston: Rice University, 21st–24th May 1978.

6 BROOKES, B. C. *and* GRIFFITHS, J. M. Frequency rank distributions. *Journal of the American Society for Information Science*, 29, January 1978, p. 5–14.

7 PRICE, DEREK DE SOLLA. A general theory of bibliometric and other cumulative advantage processes. *Journal of the American Society for Information Science*, 27, September 1976, p. 292–306.

8 BROOKES, B. C. A sampling theorem for finite discrete distributions. *Journal of Documentation*, 31, March 1975, p. 26–33.

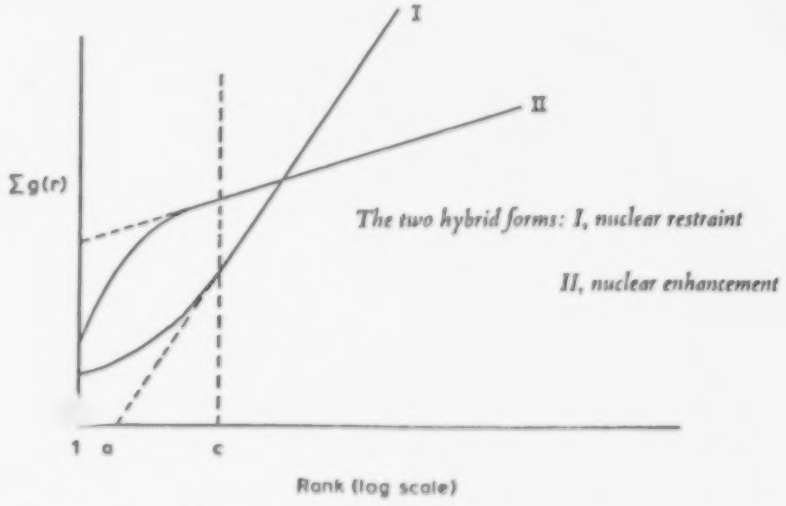

## ACKNOWLEDGEMENT

The data discussed here was developed, and the work of one of the authors, Belver C. Griffith, was funded, under grant number R01 LM00911-06 from the National Library of Medicine, Washington, D.C., U.S.A.

## 4.2 Ernährungswissenschaftliche Literatur / Agrarwissenwissenschaftliche Literatur

Maheswarappa (1982) analysierte die Referenzen, welche den drei wichtigsten Zeitschriften für Ernährungswissenschaften beigefügt sind. Die Ursprungsländer der Zeitschriften waren die USA, Großbritannien und Indien. Die wichtigsten graphischen Darstellungen, eine Liste von 62 Kernzeitschriften, ihr Herkunftsland und die Alterung der Artikel wurden angegeben.[31)]

Die nachstehende Graphik zeigt das Ergebnis einer Untersuchung Reilly's. Forschungsobjekte waren Zeitschriften des Fachgebiets Agrarwissenschaft aus der gesamten Weltproduktion. Die Quellen waren die natürlichen Sprachen Englisch, Französisch, Deutsch, Russisch, Spanisch etc. (vgl. Abb. unten)




Die von Brookes (1977) nachuntersuchten Daten Reilly's ergaben die in obiger Abbildung dargestellten Verteilungen.

31) Maheswarappa, B. S.; Surya Rao, K.: Journal literature of food science and technology
Ann. of. libr. sci. and docum. 29(1982)3, pp. 126-134

Graph I zeigt einen eingeschränkten Kernbereich, Graph II eine erweiterte Kernzone. Den mathematischen Hintergrund gibt Brookes (1977, S. 193).[32)]

Die Genauigkeit der (relativ einfach durchzuführenden graphischen Methode) wurde von Wilkinson (1972) getestet. Sie fand für vier Fachgebiete (Landwirtschaftliche Volkswirtschaftslehre, Muskelfasern, Mastzellen, parasit. Egel) eine hinreichende Genauigkeit um die Anzahl der Zeitschriften und die Totale der Publikationen abzuschätzen. Bei großen Datenmengen (über 10.000 Publikationen) betrug der Fehlerbereich 1 - 5,2 %.

Die Autorin schließt: die graphische Formulierung der Bradford-Regel beschreibt mit guter Annäherung die reale, für den Praktiker wichtige Situation. Mit einem Minimum an beobachteten Daten könne die Totale für Zeitschriften und Aufsätze (zu spezifischen Themen) geschätzt werden; der "Kern" für beide Informationsquellen ist gut zu identifizieren.[33)]

**COMPARISON OF RESULTS FOR TOTAL NUMBER OF JOURNALS**

| | p | q | S | Observed total | Graphical formulation Estimated total | % error | Verbal formulation Estimated total | % error |
|---|---|---|---|---|---|---|---|---|
| Agricultural economics | 40 | 191 | 3,454 | 2,116 | 2,210 | 4.4 | 2,586 | 22.1 |
| Muscle fibre | 25 | 176 | 604 | 313 | 310 | -1.0 | 331 | 5.8 |
| Schistosomiasis | 20 | 126 | 3,023 | 1,738 | 1,643 | -5.5 | 1,807 | 4.0 |
| Mast cells | 20 | 85 | 768 | 587 | 531 | -9.5 | 642 | 9.5 |

**COMPARISON OF RESULTS FOR TOTAL NUMBER OF PAPERS**

| | p | q | S | Observed total | Graphical formulation Estimated total | % error | Verbal formulation Estimated total | % error |
|---|---|---|---|---|---|---|---|---|
| Agricultural economics | 40 | 191 | 3,454 | 12,205 | 12,320 | 1.0 | 13,510 | 10.5 |
| Muscle fibre | 25 | 176 | 604 | 1,346 | 1,383 | 2.7 | 1,415 | 5.1 |
| Schistosomiasis | 20 | 126 | 3,023 | 9,914 | 10,270 | 3.6 | 10,810 | 9.0 |
| Mast cells | 20 | 85 | 768 | 2,378 | 2,502 | 5.2 | 2,797 | 17.6 |

32) Brookes, B. C.: Theory of the Bradford law
J. of docum. 33(1977)3, pp. 180-209

33) Zur Theorie und Praxis des modernen Bibliothekswesens. - Bd. 3. - München, 1976. - S. 14-23

## 4.3 Geographische Literatur

Von Aiyepeku (1977) wurde die gesamte Weltproduktion geographischer Literatur von 1970-1973 untersucht. Weiter wurde für den gleichen Zeitraum die Produktion geographischer Literatur, welche die Länder USA, Britische Inseln, Frankreich und Deutschland betraf, untersucht.[34] (Siehe nachstehende Abb.)

*Cumulation of USA, British Isles, France, and Germany data*

| *Zone* | *No. of periodicals* | *No. of articles* | *Ratio* |
|---|---|---|---|
| 1 | 6(=c) | 316 | — |
| 2 | 11 | 317 | 1·8 |
| 3 | 18 | 318 | 1·6 |
| 4 | 29 | 333 | 1·6 |
| 5 | 53 | 334 | 1·8 |
| 6 | 110 | 316 | 2·0 |
| 7 | 154 | 161 | 1·4 |
| | 381 | 2,095 | Mean = 1·8* |

* Computed without zone 7; with zone 7, Mean = 1·6.

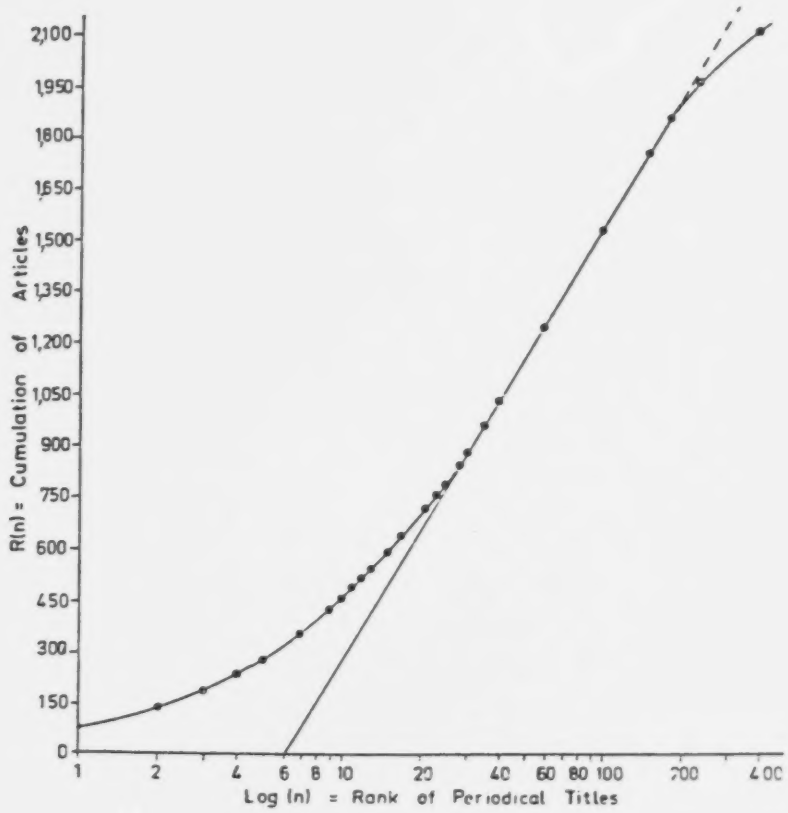
*Bradford distribution of geographical literature into equal productivity zones: world data**

| *Zone* | *No. of periodicals* | *No. of articles* | *Ratio* |
|---|---|---|---|
| 1 | 15 (=c) | 2,195 | — |
| 2 | 31 | 2,181 | 2·0 |
| 3 | 52 | 2,208 | 1·7 |
| 4 | 87 | 2,197 | 1·6 |
| 5 | 171 | 2,194 | 1·9 |
| 6 | 204 | 2,194 | 1·1 |
| 7 | 500 | 895 | 2·4 |
| | 1,060 | 14,064 | Mean = 1·7 |

* Since the titles of Tables 1–6 are exactly the same except for the areas, the titles of Tables 2–6 will indicate only such areas.

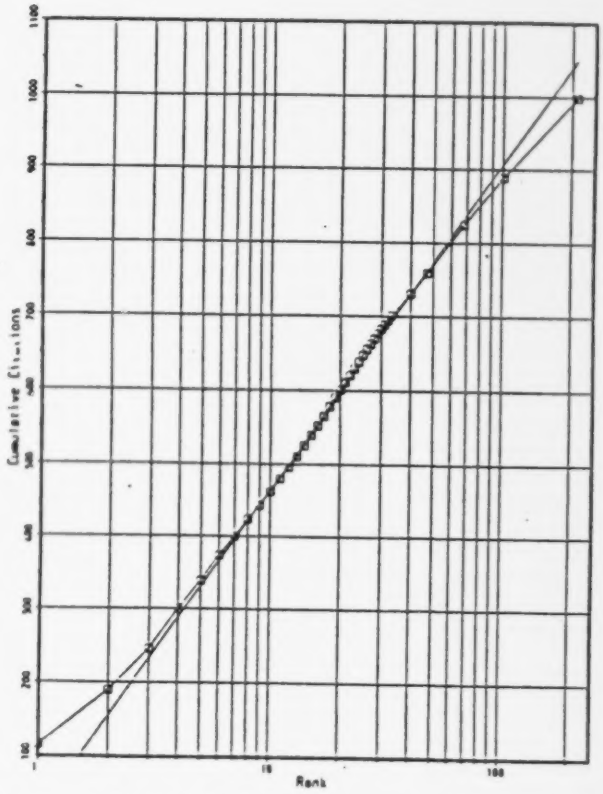
34) Aiyepku, W. O.: Bradford distribution theory
J. of docum. 33(1977)3, pp. 210-219

Convolution of correlated and uncorrelated Bradford distributions for USA, British Isles, France, and Germany



## 4.4 Chemische Literatur

Hawkins (1978) untersuchte unter Anwendung des "Law of Scattering" die Quellen der Literatur über Edelgasgemische. Wie aus der Graphik zu entnehmen ist, sind bereits 700 Literaturzitate in 35 von 200 Zeitschriften enthalten; d.h. 17,5% der Quellen ergeben 70% aller Nachweise.[35)]




Bradford plot for noble gas compounds.

35) Hawkins, D. T.: Literature of noble gas compounds
J. of chem. inform. and comput. sci. 18(1978)4, pp. 190-199

## 4.5 Sozialwissenschaftliche Literatur

Subramanyam (1976) untersuchte die Regel für die Bestimmung der Kernzeitschriften im Gebiet der Computerwissenschaft. (Vgl. Tab.)[36)]

Dispersion of Computer Science Literature

| Type of document | References cited in *Computing Reviews* | | References cited in *IEEE Transactions on Computers* | |
|---|---|---|---|---|
| | Number of references | Percentage | Number of references | Percentage |
| Journal articles | 2,050 | 48.71 | 2,124 | 42.63 |
| Conference papers | 1,015 | 24.12 | 556 | 11.16 |
| Books | 905 | 21.50 | 1,839 | 36.91 |
| Technical reports | 108 | 2.57 | 314 | 6.30 |
| Dissertations | 67 | 1.59 | 104 | 2.09 |
| Theses | 52 | 1.23 | 28 | 0.56 |
| Miscellaneous | 12 | 0.28 | 17 | 0.35 |
| Total | 4,209 | 100.00 | 4,982 | 100.00 |

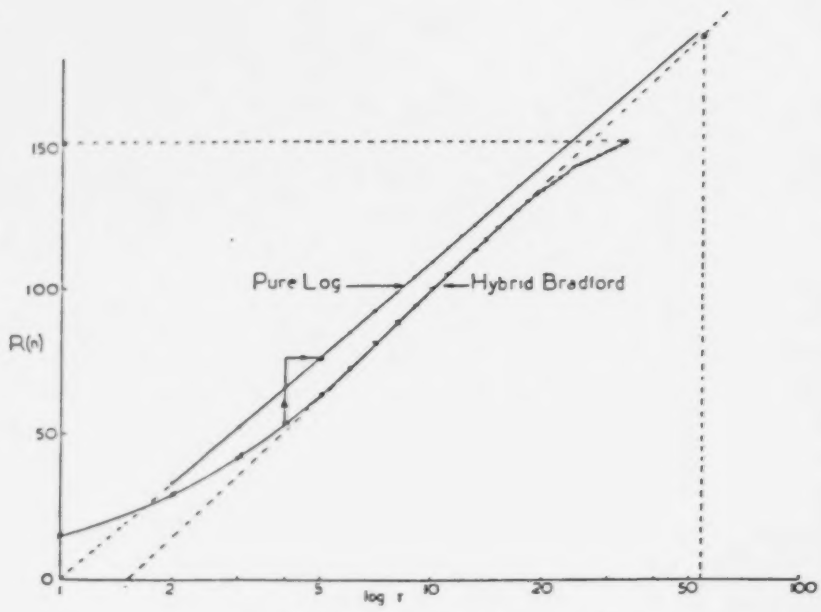
Gordon (1982) stellte fest, daß allgemeinwissenschaftliche und sozialwissenschaftliche Titel in größerem Umfang als humanwissenschaftliche Titel benutzt werden.[37)]

36) Subramanyam, K.: Core journals in computer science IEEE transactions 19(1976)2, pp.22-25

37) Gordon, M.: Periodicals use at a small college library Serials libr. 6(1982)4, pp. 63-73

Bei einer 3-tägigen Konferenz mit 52 Teilnehmern wurde die Mitwirkung jedes einzelnen Teilnehmers aufgelistet. Unter Mitwirkung wird die Teilnahme an Diskussionen über die gehaltenen Vorträge verstanden. Die Summen wurden in der folgenden Abbildung graphisch dargestellt.[32)]

Diskussions-
beiträge

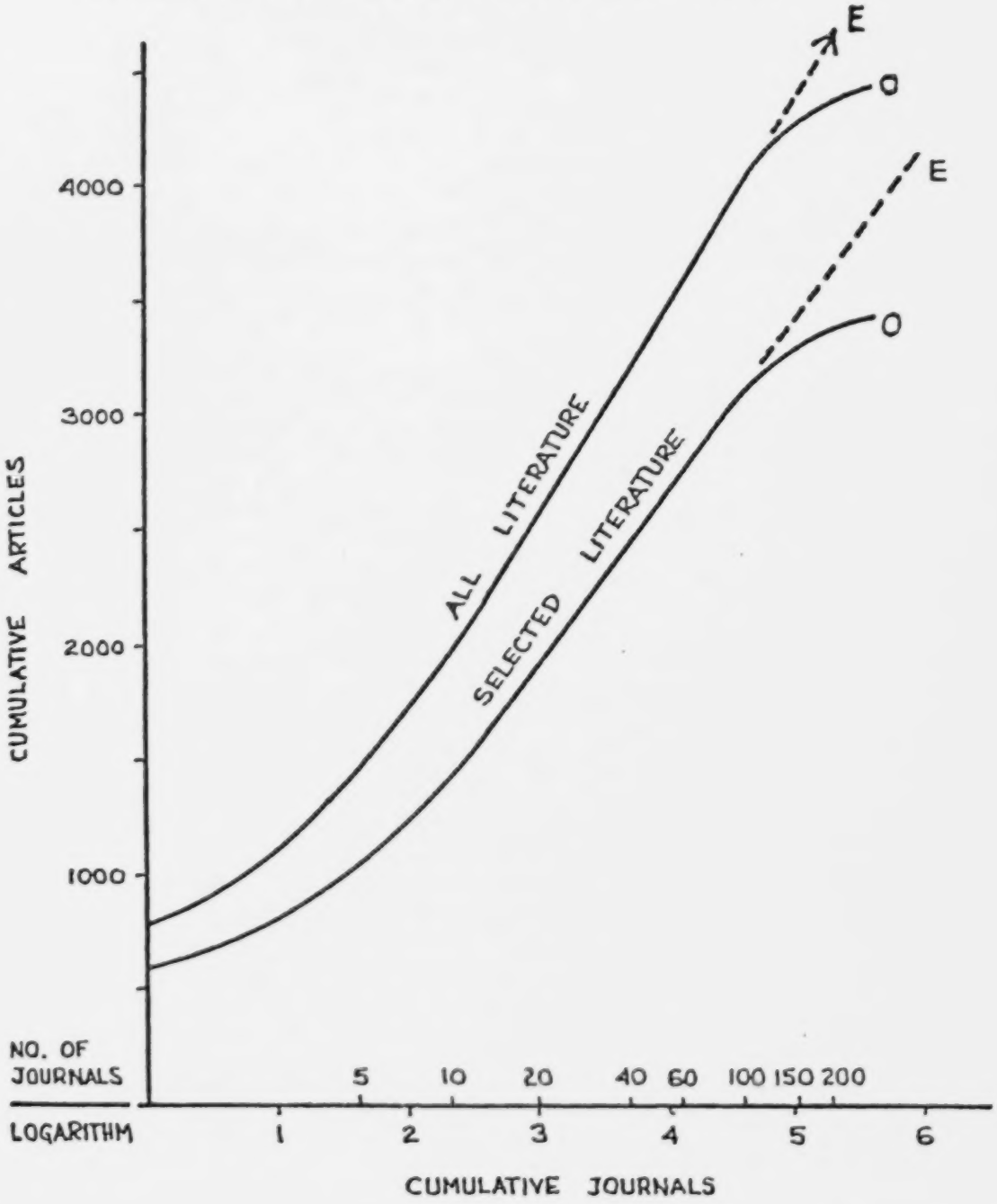



*Bradford distribution of conference performance*

Teilnehmer

## 4.6 Bibliothekarische Literatur

Saracevic und Lawrence (1973) analysierten eine Ausgabe des Library Literature-Sekundärdienstes quantitativ und qualitativ. Die Streuung der Artikel folgt fast genau der Bradford-Verteilungsregel (vgl. Abb. unten).

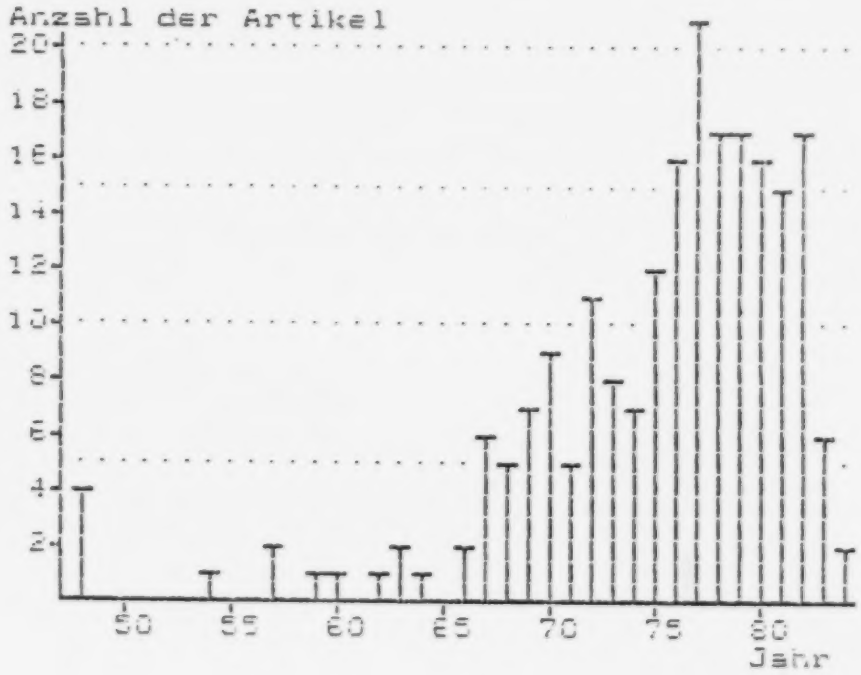


Die vorangegangene Graphik repräsentiert die Streuung der gesamten und der selektierten Artikel in den Zeitschriften. und zeigt die Differenzen zwischen den erwarteten Werten (E) und den beobachteten Werten (O) am Ende der Streuung. Die erwarteten Werte wurden nur für die selektierte Literatur angenommen.[38)]

38) Saracevic, T.; Perk, L. J.: Ascertaining activities in a subject area through bibliometric analysis
J. of the ASIS 24(1973)2, pp. 120-134

Da uns nicht nur die praktischen Anwendungsbeispiele, sondern auch die zeitliche Verteilung der gesamten von uns gefundenen Literaturnachweise interessant erscheint, folgt eine graphische Darstellung der Erscheinungsjahre und der Anzahl der Artikel. Die Anzahl der Artikel ist auf der y-Achse, die Jahre in denen die Artikel erschienen sind, auf der x-Achse aufgetragen.

Diese graphische Edition wurde mit Hilfe eines Bildschirmtextgerätes erstellt.



Zusammenfassung:

Wie die bereits dargestellten ausgewählten Beispiele gezeigt haben, ist die Bradford-Methode für die im Bereich des Bibliotheks- und IuD-Wesens vorkommenden unterschiedlichen Problemstellungen (Erwerbung, Bestandsaufbau etc.) einsetzbar.

Auch in das aktuellste "Informationszeitalter" ragt die bereits 1934 dargelegte Bradford-Methode hinein, wie die Beispiele Online und EDV zeigen. Die Auswertung unserer Gesamtbibliographie (197 Titel) gestattet es, das Interesse der Praktiker und Theoretiker an der Bradford-Methodik von 1948-1983 zu verfolgen. Die Interpretation des Diagramms der vorhergehenden Seite zeigt, daß zunächst eine sehr langsame Anlaufphase (1948-1966) erfolgt. Dieses weist auf eine nur zögernde Annahme der Bradford-Technik in der Fachwelt hin. Es folgte eine 1. Publikationswelle in den Jahren 1966-1975 und eine 2. auf nahezu dem zweifachen Output-Niveau in den Jahren 1976-1982. Der durch die Graphik signalisierte Rückgang der Publikationen ab 1983 muß noch durch weitere Recherchen widerlegt oder bestätigt werden.

# 5. Auswahlbibliographie zu "Bradford's Law of Scattering"

## Bibliographie


0 Abdelaziz Abid, M.
Techniques d'evaluation des ressources documentaires des bibliotheques universitaires
Bull. des bibliotheques de France 28(1983)1, pp. 5-25

1 Aiyepeku, W.
Bradford distribution theory : the compounding of Bradford periodical literatures in geography
J. of docum. 33(1977)3, pp. 210-219

2 Alabi, G.
Bradford's law and its application
Inter. libr. rev. 11(1979)1, pp. 151-158

3 Alabi, G.
Statistical analysis of journal usage
Int. libr. rev. 11(1979)1, pp. 141-150

4 Amba, K. N.; Rachavendran, P. R.
A technical note on Bradford's law of scatter as applied to periodical literature on leather
Ann. of libr. sci. and docum. 19(1972)4, pp. 222-224

5 Asai, I.
A general formulation of Bradford's distribution : the graph-oriented approach
J. of the ASIS 32(1981)2, pp. 113-119

6 Avramescu, A.
Coherent informational energy and entropy
J. of docum. 36(1980)4, pp. 293-312

7 Avramescu, A.
Contribution to the foundation of bibliometric laws
Stud. cercet. docum. (1973)15, pp. 3-19

8 Avramescu, A.
Theoretical foundation of Bradford's Law
Int. forum on inform. and docum. 5(1980)1, pp. 15-22

9 Ayres, F. H.; Yannakondakis, E. J.
The bibliographic record : an analysis of the size of its constituent parts
Program 13(1979)3, pp. 127-142

10 Baugham, J. C.
A structural analysis of the literature of sociology
Libr. quart. 44(1974)4, pp. 293-308

11 Baugham, J. C.
Toward a structural approach to collection development
College and res. libr. 38(1977)3, pp. 241-248

12 Becker, J.; Hayes, R. M.
Information storage and retrieval : tools, elements, theories
New York; London: Wiley, 1963. - p. 369

13 Bensman, S. J.
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# 7. Zeitschriftentitelauflösungen

| | | |
|---|---|---|
| Amer. docum. | American documentation | (US) |
| Amer. j. of med. sci. | American journal of medical science | (US) |
| Ann. of libr. sci. and docum. | Annals of library science and documentation | (IN) |
| Annu. rev. of inform. sci. and technol. | Annual review of information science and technology | (US) |
| ASLIB proc. | ASSOCIATION OF SPECIAL LIB- AND INFORMATION BUREAUS proceedings | (GB) |
| Austln. Acad. Res. Librs. | Australian Academic and Research Libraries | (AT) |
| Behav. sci. | Behavioral science | (US) |
| Bull. of the Med. Libr. Assoc. | Bulletin of the Medical Library Association | (US) |
| Bull. des bibliothèques de France | Bulletin des bibliothèques de France | (FR) |
| Cesk. inform. | Ceskoslovenská informatika | (CS) |
| Chem. age | Chemical age | (GB) |
| Collection managem. | Collection management | (US) |
| College and res. libr. | College and research libraries | (US) |
| Diss. abstr. | Dissertation abstracts | (US) |
| ICSI proc. | INTERNATIONAL CONFERENCE ON SCIENTIFIC INFORMATION proceedings | |
| IEE proc. | INSTITUTION OF ELECTRICAL ENGINEERS proceedings | (US) |
| IEEE transactions | INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS transactions on professional communication | (US) |
| IID comm. | INSTITUT INTERNATIONAL DE DOCUMENTATION communicationes | |
| Ind. eng. chem. | Industrial & engineering chemistry | (US) |
| Inform. process. and managem. | Information processing and management | (GB) |
| Int. forum on inform. and docum. | International forum on information and documentation | (NL) |
| Int. libr. rev. | International library review | (GB) |
| J. of chem. inform. and comput. sci. | Journal of chemical information and computer sciences | (US) |

| | | |
|---|---|---|
| J. of docum. | Journal of documentation | (GB) |
| J. of inform. sci. | Journal of information science | (NL) |
| J. of informatics | Journal of informatics | (GB) |
| J. of librship | Journal of librarianship | (GB) |
| J. of studies on alcohol | Journal of studies on alcohol | (US) |
| J. of the Amer. Statist. Assoc. | Journal of the AMERICAN STATISTICAL ASSOCIATION | (US) |
| J. of the ASIS | Journal of the AMERICAN SOCIETY FOR INFORMATION SCIENCE | (US) |
| Libr. j. | The library journal | (GB) |
| Libr. quart. | Library quarterly | (US) |
| Libr. resources and techn. ser. | Library resources and technical services | (US) |
| Libr. sci. with a slant to docum. | Library sciences with a slant to documentation | (IN) |
| Libr. res. | Library research | (US) |
| Libr. trends | Library trends | (US) |
| Libr. world | Library world | (GB) |
| Managem. sci. | Management sciences | (US) |
| NfD | Nachrichten für Dokumentation | (DE) |
| Nat. | Nature | (GB) |
| Online rev. | Online review | (GB) |
| Operational res. quart. | Operational research quarterly | (GB) |
| Operations res. | Operations research | (US) |
| Persiero e linguag. oper. | Pensiero e linguaggio in operazioni | (IT) |
| Probl. de inform. si docum. | Probleme de informare si documentare | (RO) |
| Proc. of the ASIS | Proceedings of the AMERICAN SOCIETY FOR INFORMATION SCIENCE | (US) |
| Proc. of the BSIB | Proceedings of the BRITISH SOCIETY FOR INTERNATIONAL BIBLIOGRAPHY | (GB) |
| Rev. Esp. Doc. Cient. | Revista Espanola de documentation cientifica | (ES) |
| Sci. and techn. inform. process. | Scientific and technical information processing (engl. Übers. von: naučno-tehničeskage informatsiya) | (US) |

| | | |
|---|---|---|
| Sci. libr. | The Heidelberg science library | (GB) |
| Serials libr. | Serials librarian | (US) |
| Socials indicator res. | Social indicators research | (NL) |
| Stud. cercet. docum. | Studii si cercetari de documentare | (RO) |
| Unesco bull. librs | Unesco bulletin for libraries | |
| ZfB | Zentralblatt für Bibliotheks-wesen | (DD) |

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